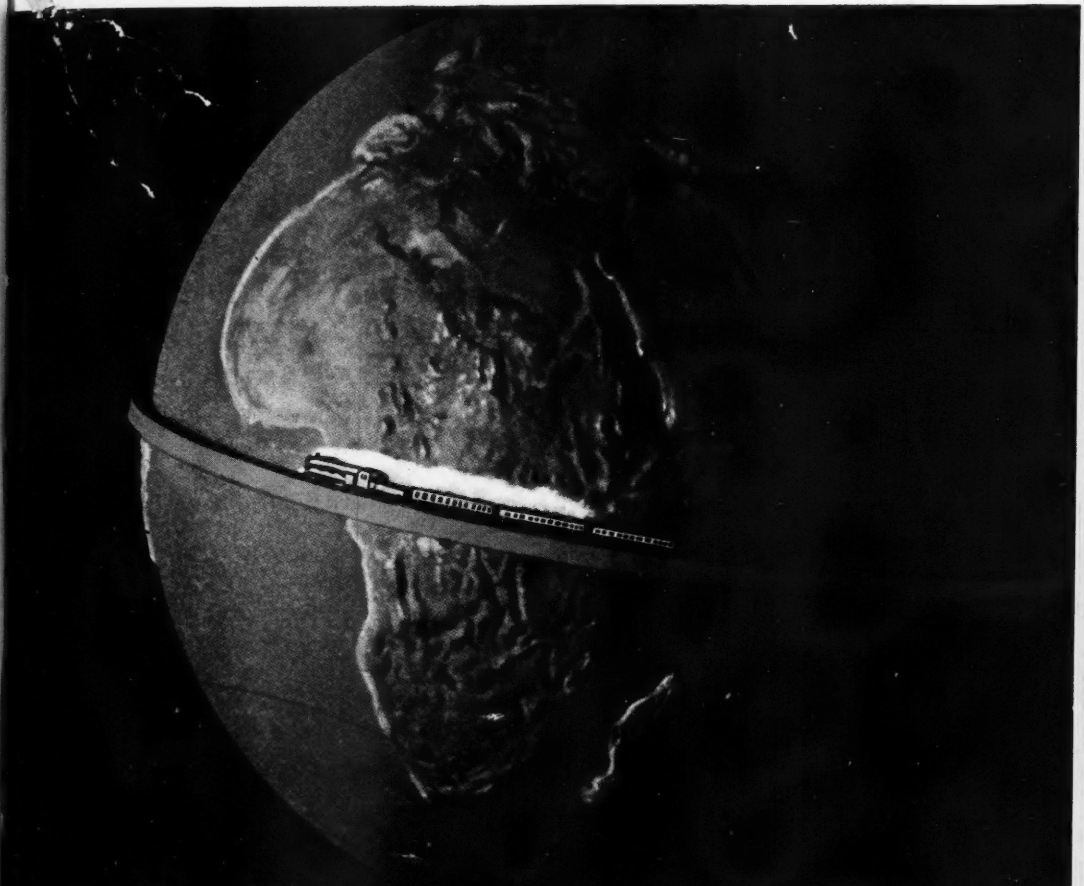
THE POPULAR JOURNAL OF KNOWLEDGE

DISCOVERY

CAMBRIDGE: AUGUST 1938



- L. INFELD on: Heavy Bricks of Matter
- The late LORD RUTHERFORD on: Forty Years of Physics
- Drugging the Public
- Rickets and Vitamin D
- The Discovery of James Boswell

ONE SHILLING net

DISCOVERY

New Series, Vol. I, No. 5 AUGUST 1938 **1*s*. net**

Published by the CAMBRIDGE UNIVERSITY PRESS, Bentley House, 200 Euston Road, N.W. 1 (Tel.: Euston 5451–3)

Editor: C. P. SNOW, University Press, Cambridge (Tel.: 4226)

Advertisement Offices: 61 Chandos Street, W.C. 2 (Tel.: Temple Bar 6897)

Annual Subscription, 12*s*. 6*d*. net post free

Drugging the Public

A Review of: PATENT MEDICINES, by Prof. A. J. CLARK. Fact No. 14

RECENTLY, I saw a man brought into hospital with diabetic gangrene of both feet. By the skill, patience and hard work of the hospital staff, one foot was saved—the other will have to be amputated. This man had had mild diabetes for three years. He had been carefully treated by diet and insulin and for two years he had had no symptoms. Then he came across an advertisement of the type so commonly seen in the press—"A new cure for Diabetes"—"No Diet—No Injections—No Drugs." He gave up his insulin and for a year treated himself with this wonderful cure. The price he paid for this treatment has been the loss of one foot—it might easily have cost him his life. An eminent medical friend of mine with whom I discussed this case recalled several similar instances of patients who had almost lost their lives through self-medication by proprietary "cures". He mentioned cases of severe haemorrhage or of peritonitis following gastric ulcer where the patients had attempted their own cure by well-advertised "Stomach powders". "If I were a Dictator," this doctor said, "the first thing I would do would be to prohibit the sale of patent medicines."

Most doctors can recall instances of the dangerous results which can occur from the use of much-boosted nostrums. But the state of affairs in regard to patent medicines is really much more alarming than these individual occurrences would indicate. For the blame does not attach to the unfortunate individual concerned. Prof. Clark, in this extremely illuminating little book, has built up a damning case against the press and the government. He points out that the income of several important newspapers from patent medicine advertisements is about equal to their

total profits. Three million pounds are spent each year on such advertisements. Naturally, therefore, there is likely to be silence in the press regarding the frauds and trickery of patent medicine vendors. No wonder much more publicity is given to the rare case where a doctor accidentally causes harm or injury to a patient than to the hundreds and thousands of miserable people who suffer needlessly through being deluded by the modern advertising expert. No wonder the press ignores the oft-published detailed analyses of secret remedies which are periodically made by bodies such as the British Medical Association. Prof. Clark quotes an American patent medicine proprietor as saying, "The twenty thousand newspapers in the United States make more money from advertising the proprietary medicines than do the proprietors of the medicines themselves...of their receipts one-third to one-half goes in advertising."

Prof. Clark makes a brave attempt at the almost impossible task of unravelling the present state of the law relating to the sale of patent medicines. There are two main types of these—the secret remedies, on which a stamp duty is paid, and the non-secret remedies, where the composition of the medicine has to be published. In the case of the secret remedies there is nothing to prevent a manufacturer from selling a mixture of coloured water and sugar as a cure for tuberculosis, cancer or any other disease. Prof. Clark recalls the notorious Yadil case where Sir William Pope, Prof. of Chemistry at Cambridge University, showed that it was composed of "1 % formaldehyde, 4 % glycerine, 95 % water and a smell". This preparation, reputed to cure a host of diseases including cancer and consumption, cost 1*s*. 6*d*. a gallon to produce and was sold for £4. 10*s*. a gallon. Moreover, in the case of these secret remedies, there is nothing to prevent the manufacturer changing the composition as often as he pleases or even introducing harmful substances. A famous yeast preparation, which was popular for the relief of pain, contained a drug which in several people resulted in the fatal disease agranulocytosis. Many slimming pills used to contain dinitrophenol, which has also resulted in many deaths. Both of these drugs are now, as a matter of fact, included in Schedule 4 of the Poisons List and are only obtainable under a medical prescription, but, as Prof. Clark points out, "...a number of lives have been sacrificed in a wholly unnecessary manner." In the case of the non-secret remedies where the ingredients must be stated, the manufacturers have hit upon the plan of using the complicated synonyms for the simple constituents of the mixture. These, although accurate, are only intelligible to the trained chemist. Thus, caffeine becomes trimethylxanthine, antipyrine is phenyl-dimethyl-isopyrazolon, and aspirin is acetyl-salicylic acid.

And the government? During the year 1928–9, the government received about £1,300,000 from Medicine and Stamp duties. But surely the government does something to control the scandalous swindling of the public? Well, in the year 1935–6, the revenue from the Medicine and Stamp duties had fallen to about £750,000, and so a Select Committee was appointed to investigate this matter. They reported in 1937 and made a series of recommendations—on how to increase the revenue.

But "the Bill perished chiefly because it proposed to tax cosmetics, a reasonable but highly unpopular proposal".

But the most astounding fact in regard to the sale of patent medicines is that in 1914 a Select Committee on patent medicines reported, "For all practical purposes British law is powerless to prevent any person from procuring any drug, or making any mixture, whether potent or without any therapeutical activity whatever (as long as it does not contain a scheduled poison), advertising it in any decent terms as a cure for any disease or ailment, recommending it by bogus testimonials and the invented opinions and facsimile signatures of fictitious physicians, and selling it under any name he chooses, on the payment of a small stamp duty, for any price he can persuade a credulous public to pay."

Since then nothing has been done. Prof. Clark's extraordinarily lucid and concise account of the present situation shows that such reform is even more urgent to-day. He concludes on some suggested legislative reform with which no clear-thinking individual can possibly disagree. "The clearest line for the government to take would be to say that it did not wish to tax any remedy that was beneficial to the health of the people and wished to suppress all those that were useless or harmful."

This little book should be read by every one of those millions who are continuously being bombarded by the advertisements of what is one of the most revolting trades in human history—the trade in human sickness.

JOHN YUDKIN.

Next month we shall include an authoritative scientific review on Water Divining.

* * *

Many of our readers have written to say how much they were entertained by "Inquest on Detective Stories", in April. Mr Philmore has produced another Inquest for the September number.

Breeding Time in the Gull Colonies

By F. Fraser Darling

THERE is only one pair of hoodie crows on Eilean a' Chleirich and as they do not have the chance to make much mischief, I leave them alone. They are wild, cunning creatures, much harder to approach than the half-dozen ravens, which will come to within seventy-five yards of me when I croak to them.

The hoodies live in the cliffs at the north-western corner of the island, near the biggest herring-gull colony. I thought it strange that the gulls did not mob the crows, especially when nesting began. The herring gulls nest on a restricted area of ground on the cliff top, just in that part where bare rock and sea pink take up equal proportions of the ground space. There is a great to-do all day long at the nesting season, for the birds are ceaselessly active in feeding, courting and making their nests. And here were the hoodies walking to and fro in the gullery and picking up a harvest of scraps left by the gulls. When eggs appeared in the open nests of the gulls, I was surprised to find that the crows still walked unmolested about the gullery and, strange to relate, I did not find any sucked eggs there.

Here is the other side of the story. The lesser black-backed gull nests on the island also, but ten days or a fortnight later than the herring gull. Although the

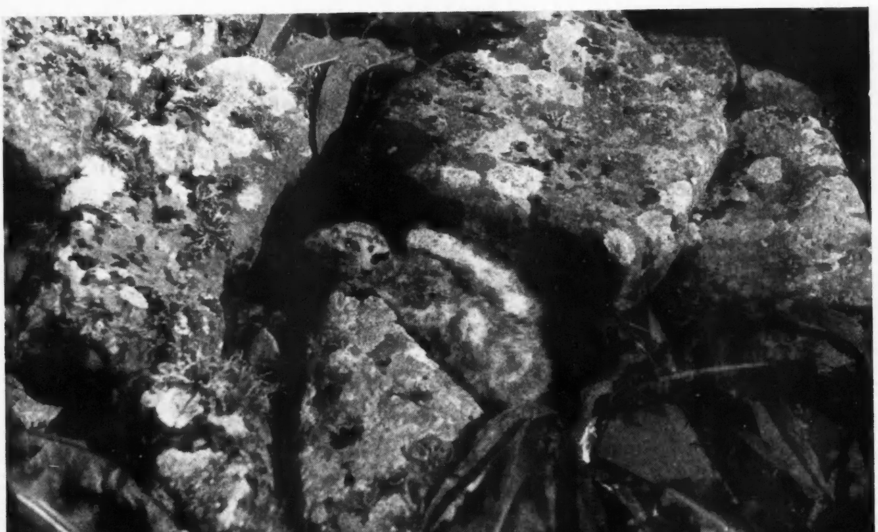
A greater black-backed gull chick

A pair of herring gulls, the female on the nest

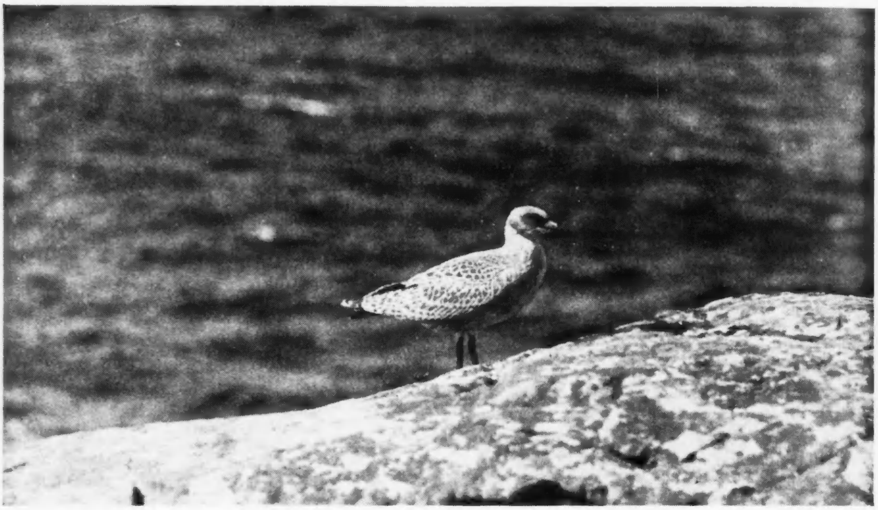
lesser black-backs are gregarious, they do not nest in such close formation as the herring gulls. Their nests may be thirty, fifty, or eighty yards apart, instead of the three, five, or ten yards between the nests observed in the herring gullery, and they nest inland on the heather ground round about the numerous freshwater lochs of the island. Sometimes I heard a tumult among the lesser black-back colony, and if I was near, I found it was always that the hoodie crows were being mobbed by seventy or eighty angry gulls. There were also a few sucked eggs about. I arranged a hide later, in a position where I could scan a fair number of nests; and, sure enough, one day I saw the crows stealing eggs. How unobtrusively they came, how quiet they were, and how discreetly they left after cleaning their beaks!

What was I to think of this social complex among my birds in which the crows took the eggs of one species and not of another closely allied? And I defy most people to tell the difference between a series of eggs of one species and of the other. The eggs of both have an olive-green or brown background and are heavily blotched with black. My conclusion was that the hoodie crows were sharp enough to learn that where the nests of the whole colony were concentrated on a small area of ground, as in the herring gullery, there would be little chance of their sucking eggs unobserved. But where the nests were scattered, as were those of the lesser black-backs, there were more and better opportunities for a sly theft.

Herring-gull chicks



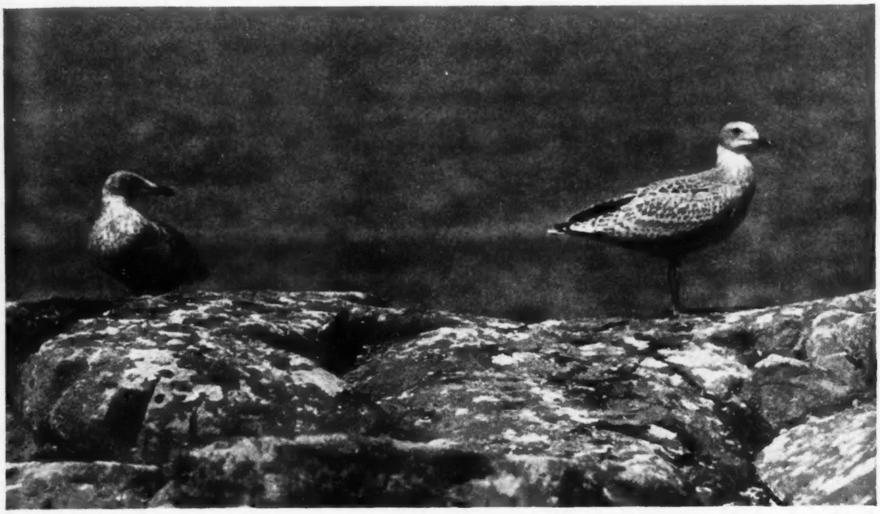
A fortnight-old herring gull hiding in lichened rocks



Why then, I wondered, should the black-backs nest in extended order when there were such manifest advantages in nesting close together? The best course was to wait and see—a sound maxim for the observer of animal life.

Hatching began in all these nests about twenty-three days after commencement of incubation. In the West Highland spring much can happen in this time. Vegetation in particular undergoes a transformation. When hatching began among the lesser black-backed gulls, the nests were no longer so open to the sky as they had been when the eggs were newly laid. Bracken, grass and heather had grown up and had I not known the positions well, it would have been difficult to find the nests again. The conditions in the herring gullery on the cliffs above the sea were very different, for there the short herbage of sea pinks, sheep's fescue grass, and saxifrages gave little more concealment to the nests than it did over three weeks ago.

And now I was to observe a difference in the behaviour of the black-back chicks and those of the herring gulls—a strange thing really, when you consider how very much alike are the adult gulls and how they often mix together in their ordinary life. I am still unable to decide whether the difference in behaviour is markedly inherent or largely dictated by the variations in the environment of the two species of chicks. The young black-backs seemed extraordinarily active from the first day they were hatched, and it was amusing to see the speckled mites swimming about on the freshwater lochans. Indeed, it was not easy to find the little black-backs during the first week or two of their lives, because they would run under the bracken and long heather. The herring-gull chicks sat about among the nests and would squat between two stones at the slightest hint of danger. They matched the



Young herring gulls

background of lichened rock perfectly. I was able to make accurate counts of the chicks of both species at the time when they began to fly. The herring-gull fledglings learned to fly by dropping into the wind from the cliff edge, and the lesser black-backs by fluttering into a strong wind off the water of the lochans.

The hoodie crows have now passed out of the picture, but there are other bold bad barons in the lives of the gulls. The greater black-backed gull and the heron both prey on the herring-gull and lesser black-back chicks. The heron is mobbed at sight by both species, but the greater black-back often passes unnoticed in his depredations, possibly because he bears a resemblance to their own kind. The herring gulls lost a good many chicks in this way, and it was interesting to find that the larger colonies lost fewer than the smaller ones. For example, the colony of ninety birds lost about half their chicks, the colony of thirty-four about two-thirds, and the smallest colony of twenty birds lost nearly three-quarters of the chick crop. The lesser black-backs were more fortunate, for they did not lose more than about a third of the total number of their chicks to predatory birds. Of course, as soon as the chicks of both species were fledged and had begun to fly, the peregrine falcon took her toll, but her affairs are outside the present discussion, which is to show that the close-nesting species nested on ground where there was no cover (other than that provided by camouflage), and that the gulls which nested in extended order were found on ground where cover was ample after the chicks hatched. Indeed, the scattered nature of this colony actually gave protection to the lesser black-backed chicks. The herring gulls find their protection in close colonization, but there is no

doubt that they pay a heavier toll in chicks for their preference of the open ground on top of the cliffs.

These few figures which I have presented may suggest a reason for a statement which is often heard in areas where herring gulls have nested since time immemorial, and where the lesser black-back has come in more recently. People say the lesser black-back is *driving out* the herring gull. I doubt whether that can be supported by observation. More correctly, I think it should be said that the lesser black-backed gulls are more successful in rearing their chicks.

The picture at the beginning, on p. 214, shows the north-western corner of Eilean a' Chleirich. The sea is calm after a bad storm from the north, which means that the swell is very deep, breaking against the fifty-foot cliffs of the gullery with a great boom. We call this part the Cauldron, because it is the most turbulent bit of sea round Eilean a' Chleirich. In rough weather the spray comes out of it and is driven by the wind into the sea again on the west side.

It is difficult to imagine more perfect protective coloration than that of the young herring gull among the rocks. The lower picture on p. 217 shows a bird a fortnight old sitting motionless in a group of stones. The pattern of the lichens on the rocks of Eilean a' Chleirich is itself a study in beautiful arrangement, and it is even more striking when you find it picked up and copied afresh on the backs of the young birds squatting against the lichens.

My photograph on this page shows hatching time in a herring gull's nest. One chick is out and dry and therefore looks much bigger than its fellow which is

still wet and resting after the exertion of hatching. The third has only just punctured the egg, and I am puzzled to know how the shell has been removed from round about the opening; the bird inside could not have done it. This picture is typical, except that there is rather more grass in the nesting material than is usual in a herring gull's nest. The chickweed grows close under the rock, the sea pinks are here and there, and the empty shells litter the edge of the nest.

The concluding photograph of a young lesser black-backed gull is rather a hoax. It was not nearly so cleverly snapped as it looks. When I see the young birds swimming about on the calm lochans, I think how nice the water pattern would be in a photograph. On this day I caught my youngster by the water's edge, set my camera stop and focus all ready, held the camera to my eye with the right hand and liberated the gull with the left—and there you are. You will notice that the bird swims away as hard as he can, but there is no flapping of the wings for as yet they are useless to him.

Heavy Bricks of Matter

By L. Infeld

(Dr Infeld describes some of the ideas in Bohr's new theory of the nucleus. These ideas represent the most significant advance in nuclear physics for years. Dr Infeld's is the first popular exposition of them which has appeared anywhere.)

Elementary Particles

The earth, the sun, the planets, tables and chairs, men and beasts, in fact, anything we chance to mention is composed of the same kinds of elementary particle. The tremendous variety of elements is due only to different composition; the material, the bricks from which matter is built, is the same in all cases. Our whole universe is made up of elementary particles of only a few different kinds. What are these particles?

Ten years ago it was easy enough for the physicist to answer this question. He would only have mentioned two kinds of particle: the *electron* and the *proton*. To-day the answer is far more complicated. We must assume the existence of other kinds of particle. The existence of two of these other kinds, the *positron* and the *neutron*, has been thoroughly established both by theory and experiment. There seems to be little doubt that other elementary particles exist, but at present we know much less about them. Let us forget, for a moment, the experiments and the speculation made about the existence of any elementary particles except the four just mentioned. We shall give our attention to the four elementary particles of matter which we can rewrite in slightly different order:

I: electron—positron.

II: neutron—proton.

Thus we have divided the particles into two groups which we shall call:

I: electron, positron—light particles.

II: neutron, proton—heavy particles.

So far we have merely noted dogmatically some of the results of years of experiment and quoted some of the terms used. We have a host of questions to ask. What experiments led physicists to believe in the existence of these elementary particles? How are the atoms, the higher organisms of matter, built up of these particles? What are the properties of these elementary particles and what forces act between them? To answer all these questions here would mean giving a full description of modern quantum physics and running the risk of treating the most important problems of contemporary physics hastily and superficially. We should be wise to restrict our problems. Our aim here is to sketch the ideas recently introduced into the problem of nuclear physics by Niels Bohr. Let us, therefore, deal only with the problem of heavy particles, that is, neutrons and protons, ignoring the light ones altogether for the time being. Why do we call neutrons and protons *heavy* elementary particles? Here "heavy" is certainly a relative concept. The mass of a heavy particle is extremely small when compared with any mass which can be determined by a scale. We know what is meant by "one gram". This is a small weight familiar to everyone.

But imagine, if you can, a mass one millionth of a million times smaller. Even this would still be far removed from the mass of a proton or a neutron. Small as this mass is, it must still be diminished millionths of a million times to obtain a mass of the same order of magnitude as that of a proton or a neutron. The mass of a proton or a neutron is actually:

0·000 000 000 000 000 000 000 0017 gram.

Why do we call these particles, which weigh so little, the "heavy particles"? We are certainly not trying to be funny! The reason is that the proton or the neutron is about 2000 times heavier than the electron or the positron. We shall understand these remarks better if we return to our example of the one gram weight. Our weight, like all matter, is a collection of light and heavy elementary particles. We can imagine a strange thing happening. Some peculiar force tears all the light particles from our piece of metal, leaving only the heavy ones. This would completely change most of the properties of our metal. But its mass would remain almost unchanged! The heavy particles are responsible for the mass of all bodies; addition or subtraction of light particles changes this mass only very slightly.

We have already stated the figure expressing the mass of a heavy particle; proton or neutron. Does this mean that these two kinds of particle both have the same mass? If we do not wish to be too pedantic we may say yes. To be more precise: the difference between the mass of a proton and that of a neutron is very small. There is, however, an essential difference between these two masses. The proton has an electric charge but the neutron has none. The neutron is electrically neutral, hence the name. The proton has a small positive electric charge called the *elementary charge*. We could ask how great, or rather how small, is this charge. To quote the figure we should first have to know the accepted unit for measuring charges. Here we shall only state vaguely that the elementary charge is extremely small. Thus the proton is the source of an electric field, whereas the neutron is not. This is why the existence of the proton was discovered long before that of the neutron. Since the proton has its own charge, its path under the influence of other electric and magnetic fields could be traced. Its behaviour in an external field enabled us to determine its mass and charge. The discovery of the neutron and the determination of its mass were much more difficult and were only made possible by complicated experiments.

We must now say a few words about the more complex organisms, atoms which are built up of elementary particles. I can think of no better comparison than the one generally used: the atom-planetary system. The heavy nucleus of the atom, in our comparison the sun, is composed of heavy particles, that is, of neutrons and protons. The planets are the electrons, the light particles surrounding the heavy nucleus. The heavy elementary particles appear only in the nucleus, the innermost and heaviest part of the atom. Repeating our previous remark we could say: if we could tear out from the atom (planetary system) the electrons (planets), leaving only the nucleus (sun), we should essentially change many properties of the atom; the mass, however, would change only very slightly because the mass is concentrated in the nucleus composed of heavy elementary particles: charged protons and uncharged neutrons.

Nuclei

We have two boxes containing small balls, each with the same mass. The only difference between them is that in one box the balls are smooth, and in the other each ball is marked with a + sign. The smooth balls represent neutrons and those marked + represent protons. We take a handful of each kind of ball and throw them both on to the same plate. We now have a collection of protons and neutrons on the plate. Unless our choice is particularly unlucky, such a collection should represent a picture of

the nucleus of some element. This is, of course, a very rough but useful model of a nucleus.

A few examples will make this clearer.

We take out 13 smooth balls (neutrons) and 14 balls marked + (protons) and throw them on to the plate. This gives us the model of a nucleus of aluminium. We then take out 138 smooth balls (neutrons) and 88 balls marked + (protons) and throw them on to the plate. This time we have the model of a nucleus of radium.

Now for the simplest example.

We throw one ball marked + (proton) on to our plate. This is the model of a nucleus of the lightest and simplest of all elements—hydrogen. A proton is the nucleus of hydrogen!

There is already one + ball on the plate and we now throw on a smooth one. Thus we have the model of a very simple nucleus composed of one proton and one neutron. Which nucleus does this model represent? We understand that the answer to this question will enable us to comprehend the role of the neutron in a nucleus. The answer is: we again have a model of a hydrogen nucleus, but the mass of this hydrogen nucleus is twice as great as that of the first which consisted of only one proton. Generally speaking, the addition or subtraction of one neutron does not change the element. If, previously, we had an atom of hydrogen, aluminium or radium, then, even after the addition or subtraction of one or more neutrons, we still have an atom of hydrogen, aluminium or radium. If the nuclei differ *only* in the number of neutrons, we say that we have different *isotopes* of the same element. Different kinds of isotopes have a different number of neutrons in the nucleus. But, if the isotopes are of the same element, their nuclei have the same number of protons. Or, in other words, isotopic nuclei have the same charge, but different masses. If a neutron is added or taken away the physical and chemical properties generally remain unchanged. The element is still the same.

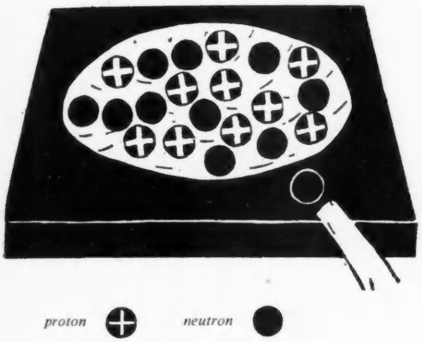
If a proton is added or subtracted, however, the situation changes. We have, for example, our model of heavy hydrogen: proton and neutron. We add a proton. We obtain the model of a nucleus of another element, the second lightest, *helium*. Again adding a smooth ball (neutron) we still have the nucleus of helium but of a different atomic mass. We could follow similar processes with other nuclei. The number of protons in the nucleus decides the element. Addition or subtraction of protons changes our model of a nucleus of one element into that of another.

Our model of a nucleus as a plate on which balls are thrown is certainly a naïve picture. By the addition of protons we create in a simple way models of nuclei of new elements or, by the addition of neutrons, models of new isotopes. One of the greatest achievements of modern experimental physics is the realization of intricate and ingenious experiments corresponding to our naïve picture. Many experiments of this kind have been performed at the Cavendish Laboratory in Cambridge, directed by Lord Rutherford. There also Chadwick discovered the neutron. By bombarding elements with neutrons or rapidly moving protons we can change one element into another. The statement that modern physics has realized the dreams of the alchemists conveys some meaning even though it sounds trivial.

Bohr's New Idea

We now come to the new ideas introduced by Bohr. Let us once more imagine the previously described model, but this time on a larger scale. The size of our plate is increased to, say, that of a billiard table, and the balls are as big as billiard balls. Again some of them are smooth and others are marked +. We throw another smooth ball representing a neutron on to the table with a comparatively large velocity. In our model, this is the picture of a nucleus being bombarded by a fast neutron. The

billiard table is the scene of a process which, as Bohr rightly remarked, is indeed very complicated. The thrown ball bumps into many of the balls on the table and causes a large number of collisions. Let



us consider a few of the things which may happen:

1. It may happen that, after a number of collisions, the energy of the thrown ball will divide itself among the other balls, increasing their motion in an irregular way so that none of them will have enough energy to leave the table. We remember: the table is in the form of a plate and some energy is necessary for one of the elementary particles to leave it. If the energy of the thrown neutron is divided between many elementary particles and they all remain in the nucleus, then we obtain an isotope of the previous nucleus as a result of the bombardment.

2. It may happen that the energy of the thrown neutron will not be distributed among many other particles. Perhaps after many complicated collisions between the balls a proton, say, will collect sufficient energy to leave the plate-like table. Result: one neutron enters, one proton goes out. We shall, therefore, obtain a nucleus of a different element.

3. Yet another process is possible. Again after many irregular collisions, it may happen that it is a neutron and not a proton which is collecting energy to leave the plate-like table. In this case the result is: one neutron enters, one neutron goes out. We shall, therefore, retain the same nucleus.

To summarize we can say: three things may happen as the result of bombardment by a neutron. We may obtain an isotope, a new element, or we may have the same nucleus as before the bombardment.

Perhaps our picture is less naïve than one would be inclined to think. I have, indeed, seen this picture and model used by Bohr during a lecture in Princeton. This picture shows in a very suggestive way the complicated character of nuclei processes. Even in case (3) when apparently nothing happens, the process is, in fact, very complicated. It could be said that just a neutron comes in and a neutron goes out. This must, however, be pictured as the result of a great number of irregular collisions which cannot be described in detail.

But the problem is still more complicated. We have already quoted some data concerning the mass of a neutron or a proton. On the basis of some experimental and theoretical investigations, we can also answer the following question: what are the dimensions of these elementary particles? The answer is a fantastically small number of the order of a millionth of a millionth of an inch. Even the extremely small dimensions of an atom are bigger than those of the elementary particles constituting the nucleus, just as the dimensions of our planetary system are bigger than those of the sun.

We have characterized the dimensions of an elementary particle. Now another question: what are the dimensions of an atomic nucleus? It would seem that the nucleus must be big compared with the elementary particles. Is not the nucleus a congregation of elementary particles? But, strange as it seems, experiment shows that this is not so. The dimensions of the nucleus are of the same order as those of the elementary particle. How is this possible? How is it that a handful of balls

thrown on to a plate has dimensions of the same order as each individual ball? Bohr's fundamentally new ideas about the constitution of the nucleus are strictly connected with this problem. The principal idea can be formulated in one sentence. There is little use in considering the nucleus as a congregation of elementary particles. The nucleus should not be considered as a collection of elementary particles. This is especially true of heavy nuclei in which there is a great number of protons and neutrons. These lose, so to speak, their individuality. The heavy nucleus ought not to be compared to a handful of small balls. The complete nucleus behaves rather like a homogeneous *drop of liquid*.

Hydromechanics and thermodynamics are familiar old branches of classical physics, most successfully applied in the range of *macrophysical* phenomena, that range which lies in the region of our immediate sensuous impressions. Quantum mechanics formulates new methods of thought which are well suited to the description of *microphysical* phenomena, in the investigation of the atomic structure. But the same method, though so successful in its description of the phenomena of the outer part of the atom, the light particles, does not work so well in the realm of nuclear phenomena.

Modern physics now tries to apply, at least partially, the old classical methods in the region of nuclear phenomena, especially for heavy nuclei. In Bohr's new picture we speak of "decrease in temperature of the nucleus". This phrase must not be taken too literally. A nucleus in which a neutron has been smashed is in an excited state and its behaviour can be described by similar concepts to those which we use to describe rising temperature in a solid body. If a neutron is thrown out as the result of a collision, then again an analogy with evaporation forms a picture which will help us to understand the observed phenomena.

In Bohr's theory we see one of many instances in science where a well-chosen analogy is of the greatest help. We are still far from a simple theory of nuclear phenomena. We have an overwhelming knowledge of facts, and theory lags far behind our experimental data. Bohr's new ideas are undoubtedly a great step forward, although the theory of the nucleus is still far from the state which the quantum theory has acquired for the description of the exterior of the atom.

On the opposite page we begin the third in the series of lectures on the history of science, arranged in the first place by the Cambridge History of Science Committee. Our June number included *The History of Research on Digestion and Pernicious Anaemia*, by Professor John A. Ryle; this was followed, in July, by Sir Arthur Eddington's *Forty Years of Astronomy*. Next month Professor R. C. Punnett closes the series with *Forty Years of Evolution Theory*.

Forty Years of Physics

By the late Lord Rutherford

I. The History of Radioactivity

> *NOTE*
>
> *These two lectures were delivered by the late Lord Rutherford. He had intended to write them in a form suitable for publication, and for that purpose he had arranged that a stenographer should be present, and a verbatim account of the lectures was prepared.*
>
> *I have been asked by the University Press to prepare these notes for* Discovery. *Those who knew Lord Rutherford's lectures will remember how far he relied on the force of his personality at the lecture table to convey his meaning, and they will realize that a mere transcript of the shorthand notes would not be in any way suitable for a written record. I have therefore rewritten the lectures in a connected form, keeping as closely as possible to Lord Rutherford's own words. In some places the wording is entirely new, in others it follows very closely that of the original notes.*
>
> *It is hardly necessary to add that I, alone, must accept entire responsibility for any errors in matters of fact, and for any too wide divergence from the original notes.*
>
> J. A. RATCLIFFE
>
> *Cavendish Laboratory*

I PROPOSE to give two lectures, the first on the development of ideas in the subject of radioactivity and the second on the present ideas of the structure of atoms. I think that the Committee organizing these lectures has been very wise in starting off with the history of science in our age and in drawing the dividing line in the year 1895, because that year marks a clear-cut division between what we call the old, or classical, and the new, or modern, physics. It was in that year that Röntgen made the far-reaching discovery of X-rays, a discovery which had in itself and by its consequence an enormous reaction on the advance of science. I myself was fortunate in that I came to the Cavendish Laboratory to work with Sir J. J. Thomson in that transition year 1895, and I should first like to tell you something of the attitude of scientific men at that time.

Let us briefly consider what we physicists were sure of at that date. First of all, there was the famous electromagnetic theory of Maxwell which had related light and electrical vibrations, so that light was believed to be nothing more than a form of electric wave transmitted through space. From this it followed that atomic spectra, such as the bright line spectrum emitted by hydrogen when subjected to an electric discharge, were forms of electric vibration, and therefore presumably produced by a vibration of some electric charge. For this reason many theoreticians, such as Sir Joseph Larmor and Lorentz, took the view that the atom must contain electric vibrators, although they had no idea at first whether these were positively or negatively charged.

Another generally accepted theory was the kinetic theory of gases, which supposed that the properties of gases could be explained by the motion of molecules, and, as you know, it was possible, from certain experimental results, to deduce the number of molecules in a cubic centimetre of a gas,

and to estimate the size and the weight of the atoms. At this period, however, the numerical estimates made by various experts from time to time were very varied and we could only rely very roughly on the data concerning the mass or size of the atom. The reason for this uncertainty was partly that the calculations of kinetic theory were very rough and incomplete, and partly that the experimental data were not very reliable.

* * * *

Most of you will not be surprised to hear that we believed in the kinetic theory and the molecular constitution of matter, but there is one point that the young student of to-day is liable to forget, and that is that the atomic nature of electricity was also generally accepted at this time. It is true there were no clear-cut experiments leading to the idea, but it was accepted as a result of the famous deductions made by Faraday many years before, from experiments on electrolysis. Most of the credit of bringing it before the public should go to Dr Johnstone Stoney of Dublin, a philosopher whom I knew personally. He it was who saw that there must be a fundamental unit of charge carried by the hydrogen atom in the electrolysis of water, and in giving a name to that charge he coined the word electron, now applied universally to that charge.

We must now consider the state of knowledge in those branches of chemistry with which we shall be concerned to-day. As a result of centuries of industrious work the chemists had succeeded in separating and refining the great majority of the elements, and the idea had arisen that the atoms of a particular kind of matter were all made on the same pattern. They were unchangeable and indestructible, and they would last for ever, or as long as any chemical knowledge would last. Although the old idea of the solid "billiard-ball" atom had been completely discarded by the end of the last century, the chemist still felt confident that with the methods at his disposal the atoms were unchangeable and definitely indestructible. Occasionally someone thought he had transformed one kind of atom into another, but it had always been possible to prove him wrong.

There had been developing at the same time that great generalization known as the periodic law, by which the properties of the elements were related to their positions in a list of atomic weights. The more philosophical of chemical men instinctively felt that this involved the view that atoms were either similar structures or in some way all made up from some more elementary material. But the ideas were vague, and the true meaning of the periodic law was not understood until another ten or fifteen years had passed.

Now I come to the beginning of my story. Few of you can possibly realize the enormous sensation produced by the discovery of X-rays by Röntgen in 1895. It interested not only the scientific man, but also the man in the street, who was excited by the idea of seeing his own inside and bones. Every laboratory in the world took out its old Crookes' tubes to produce X-rays, and the Cavendish Laboratory was no exception. These old tubes of Crookes showed that cathode rays have the power of causing brilliant phosphorescence in a great number of substances and it was also observed that X-rays appeared to come from the points which were struck by the rays. This led many people to think that X-rays might be connected with phosphorescence in some way, perhaps that phosphorescent substances might emit X-rays. A number of observers on the continent did experiments on this subject, among others Henri Becquerel of Paris. His father, a professor before him, had been very interested in phosphorescence, particularly in measuring its duration, and he had also been interested in the rather unusual properties shown by uranium compounds. Henri helped in his father's work and fifteen years before, in 1881, he had amused himself by making some crystals of the double sulphate of uranium and potassium, which glowed beautifully when exposed to light. In his

search for a connexion between phosphorescence and X-rays Becquerel placed a number of phosphorescent substances, enveloped in black paper, over a photographic plate, but his results were entirely negative. It then occurred to him to try his crystals of uranium salt. He first exposed them to light, so as to make them phosphoresce, and then wrapped them in black paper and placed them over a photographic plate. After an exposure of several hours and development, a distinct photographic effect was observed. The experiment was repeated with a thin piece of glass between the uranium salt and the photographic plate in order to cut off effects due to possible vapours, but the photographic effect was again obtained. At first Becquerel assumed that the emission of rays which could penetrate the black paper was in some way connected with the phosphorescence, but later he showed that the effects were just as marked if the uranium salt had previously been kept in the dark for several weeks so that there was no sign of phosphorescence. He later showed that all the salts of uranium, and even the metal itself, have the power of producing radiation which penetrates black paper. In this way he discovered the phenomenon which to-day we call Radioactivity.

* * * *

We now come to a name with which you are all familiar, that of Mme Curie. She started to investigate the activity of various substances by examining the rate at which the radiations would discharge electrified bodies placed in their neighbourhood. She found that pitchblende, and some other minerals, produced an effect greater than that of pure uranium, and she concluded that these minerals must contain some substance which was even more active than uranium. She therefore analysed them chemically, going through the ordinary processes of chemical separation and at each stage retaining that portion which showed the greater radioactivity. She found two very active substances: one which was chemically similar to bismuth she called Polonium, and the other, similar chemically to barium, she named Radium.

The amount of radium in any of the radioactive minerals is very small, of the order of 1 part in 10,000,000, but by working with tons of the original mineral Mme Curie was able to prepare enough pure radium bromide for her to determine the atomic weight of radium and to show that it had a definite spectrum, in other words to show that it behaved chemically like an ordinary element.

We are indebted to Dr Giesel, chemist of the Chininfabrik, Braunschweig, for first putting preparations of nearly pure radium salt on the market. It is said, I do not know with what truth, that he had succeeded in separating radium a little earlier than Mme Curie, but, since he had used her methods and his work was a direct consequence of hers, he had, with proper scientific generosity, refused to claim any credit for this. However that may be, the work had an important consequence, for his interest in these substances led him to put pure radium bromide on the market at £1 a milligram. I bought 30 milligrams and Ramsay did the same. A little later it cost £12 a milligram.

The discovery of radium was of the greatest importance to science, chiefly because its activity was so great, more than a million times that of uranium, that it could not be explained away as a small secondary effect. The fact that it has a long life (1600 years), and that it is easily separated chemically, also added to its importance.

It is interesting to look back and think what would have happened if the radioactivity of uranium had been discovered earlier. The element which was afterwards called uranium was discovered by Klaproth in 1789, more than a century ago, and, if he had put that substance near an electroscope he might have noticed that it discharged electricity, but in my opinion that would have been all. People would have said it was curious but would not have

thought it of any consequence. No one would have asked how the effect was produced. It is characteristic of science that discoveries are rarely made except when people's minds are ready for them.

Now I hope you will allow me to give you an account of my personal acquaintance with the subject of radioactivity. When I entered the Cavendish Laboratory in 1895 I began work on the ionization of gases by X-rays. After reading the paper by Becquerel, I was curious to know whether the ions produced by the radiation from uranium were of the same nature as those produced by X-rays, and in particular I was interested because Becquerel thought that his radiation was somehow intermediate between light and X-rays. I therefore proceeded to make a systematic examination of the radiation and I found that it was of two types, one which produced intense ionization and which was absorbed in a few centimetres of air, and the other which produced less intense ionization but was more penetrating. I called these α-rays and β-rays respectively, and when, in 1898, Villard discovered a still more penetrating type of radiation he called it γ-radiation.

In 1898 I went to McGill University, Montreal, and there I met R. B. Owens, the new Professor of Electrical Engineering, who had arrived at the same time as myself. Owens had a scholarship which required him to do some physical research, and he asked me whether I could suggest a problem which he might investigate to justify this scholarship. I suggested that he might become familiar with the use of an electroscope by studying thorium, the radioactivity of which had in the meantime been discovered by Schmidt. I assisted him with his experiments and we found some very queer effects. It appeared that the radioactive effect of thorium oxide would pass through dozens of sheets of paper put over the oxide but that it was stopped by the thinnest sheet of mica, as though something was being emitted which could diffuse through the pores of the paper. The fact that the apparatus was very sensitive to the effects of draughts supported this diffusion idea. We next did experiments in which air was drawn over the thorium oxide and then into an ionization chamber, and these showed that the activity could be transferred with the air. However, if the air current was stopped, the activity in the ionization chamber did not cease at once but gradually died away in an exponential manner. I concluded that the thorium oxide emitted a gaseous substance which I named "thorium emanation". This could diffuse through paper, and could be carried away with the air and preserved its activity for some time, decaying with a characteristic law.

* * * *

I found that this emanation had the most peculiar property that when it was passed over bodies it made them radioactive. This appeared to be due to the deposit of a material substance, rather than to any activity induced in the bodies themselves under the action of the radiation, since the amount of the material deposited could be increased by applying an electric field. Many people at this time were obtaining capricious and peculiar results from materials placed near radioactive substances, and it seemed that these could probably all be explained by the presence of emanations of the type we had found in connexion with thorium.

Before this explanation could be demonstrated to be correct it was necessary to discover the exact nature of the emanation. This was very difficult, because the amount available was always very small. Soddy and I concluded, early on, that it must be one of the inert gases like helium, neon, and argon, since it was never possible to make it combine with any chemical substance. We were able to make a rough estimate of its molecular weight by comparing its rate of diffusion with that of other gases with known molecular weights. By using the property of discharging an electroscope as a measure of the amount of emanation present, we were able to measure

these diffusion rates with very small quantities of emanation. We concluded that the atomic weight must be of the order of 100. We next tried to find whether the emanation was produced directly from the thorium, or from some intermediate product. Using chemical methods we were able to separate an intermediate substance, which we called thorium X, from which the emanation was produced.

* * * *

About this time Ramsay showed that helium was present in most radioactive minerals, and that it represented another gaseous product of the transformations. Later on I was able to show that the helium was due to the accumulated α-particles.

Radium was not available in any quantity till 1903 or 1904, and most of what there was in the world was in the possession of the Curies, who had separated it by a long and arduous process from pitchblende. One of the first observations they made was that a quantity of radium weighing about 100 mg. kept itself above the temperature of the surrounding air, and they deduced that a gram of radium would emit heat at the rate of 100 calories per hour. This experiment created great excitement, because the idea of any substance keeping itself permanently at a temperature higher than its surroundings was repugnant to the old-fashioned physicists, and the prevailing idea became common that radium had a peculiar property of acting as a thermodynamic engine using heat from the air. I was firmly of the impression that the heating effect was a necessary consequence of the emission of the α- and β-particles and that it decreased with time in the same way as the activity. Later on we were able to classify the heating effects of radioactive bodies and to show that there was nothing obscure about the process. We were able to show that heat can be evolved in enormous quantities in these radioactive changes; when reckoned per unit mass of the material, these quantities are millions of times greater than those given by chemical reactions, and we were further able to show that this is a characteristic of all radioactive changes.

Now I would like to say a little about the experimental proofs of the nature of the α-rays. By various experiments and with the help of various collaborators I was able to show, by deflecting α-particles in magnetic fields, that these particles were helium atoms carrying two positive charges, and we were also able to determine their speed. About this time (1903 and 1904) Bragg and Kleeman made their very interesting and important analysis of the ionization curve of the α-rays, showing that the ionization varied along their path in a characteristic way. A curve showing the form of this variation is now known as a "Bragg curve".

* * * *

Next I want to speak of two very important discoveries, the credit for which is due in a large measure to Prof. Soddy. I refer to the discovery of the displacement law, and the discovery of isotopes amongst the radioactive elements.

Soddy had been investigating the chemical properties of the radioactive substances, and he had noticed that there was often a simple relation between the positions in the periodic table of the original and the final elements after a radioactive disintegration. Before he could be sure of the generality of this result it was necessary to determine the chemical properties of all the known radioactive elements, not an easy matter, since many of them were only available in minute quantities. Similar work was being done by Prof. Hahn, and finally the broad generalization now known as the "displacement law" was made almost at the same time by Dr A. S. Russell, Prof. Fajans, and Soddy. This law stated simply that when a substance emitted an α-particle it moved two places down in the periodic table, and when it emitted a β-particle it moved one place up in the table. This was seen to be a consequence of the fact that

an α-particle carries two positive charges and a β-particle one negative charge.

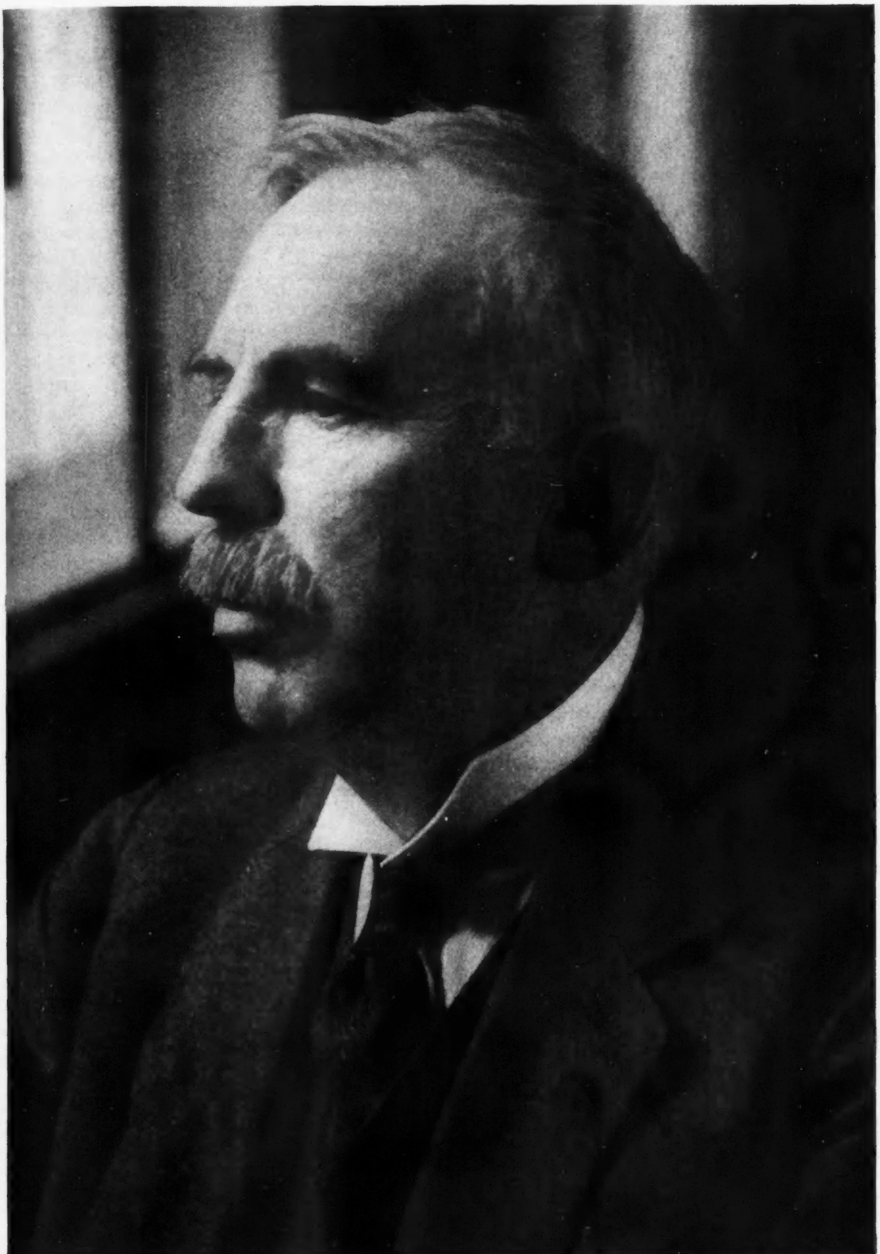
As regards isotopes the position was as follows. Many people had observed that there was an incredible difficulty, amounting almost to an impossibility, in separating certain radioactive bodies from one another. Soddy became very interested in this phenomenon and found there were some radioactive substances which he could not separate. These bodies were completely distinct and had characteristic radioactive properties, yet they could not be separated by chemical operations. He also pointed out that there was not enough room in the periodic table for the great group of radioactive elements, and he suggested that there were elements which from the chemical point of view were inseparable, but from the radioactive point of view showed different properties. Soddy called related elements of this kind isotopes, and that was the beginning of that great field of investigation which has owed so much to Dr Aston.

II. The Development of the Theory of Atomic Structure

In my lecture to-day I shall try to tell you very briefly something about the development of our ideas with regard to the constituent particles of which atoms are made, and the way in which these particles are combined to make up an atom.

One of the most important particles for our problem is the electron, and I shall try, very briefly, to show you first how our ideas about the electron have changed during the last forty years. It was in 1897 that the experiments, largely of our own leader, J. J. Thomson, led to the conclusion that the so-called cathode rays of Crookes consisted of a stream of particles of minute mass travelling with very great speeds. I believe we are right in assigning a predominant part in that discovery to J. J. Thomson, for he was the first to deflect the particles in an electric as well as a magnetic field, and also the first to recognize that the electron must be a constituent of all atoms, and he it was who first devised methods of determining the number of electrons within an atom. These early experimenters found that the ratio of the charge to the mass of the electron was about one or two thousand times greater than that for hydrogen, the lightest known atom, and at the same time they showed that electrons in a vacuum tube may have very great speeds, approaching even that of light. Now the mass of the electron was not known, only the *ratio* of charge to mass, but all the indications were that the electron was very light and mobile, and that very interesting Scotchman, Sutherland, in Melbourne, suggested that this very light electron might be nothing more or less than a unit electrical charge in motion with no material mass associated with it. J. J. Thomson had shown in 1881 that a sphere of radius a and carrying a charge e appeared to have an extra mass $\frac{2}{3}e^2/a$ corresponding to the fact that when it was set in motion energy had to be put into the electromagnetic field surrounding it. Sutherland pointed out that if the radius a were only supposed small enough there was no necessity to assume that the electron had any "ordinary" mass at all. For this to be true the radius would have to be about 2×10^{-13} cm. It was an attractive idea, and people set about trying to test its validity.

Theoreticians, such as Abraham, Heaviside, and Searle here in Cambridge, tried to find out how the apparent mass due to the charge would vary with the velocity. Different investigators arrived at different results, owing to the fact that they made different assumptions to start with, but for moderately great speeds these results were roughly the same. All showed that the mass should increase with speed and should become infinite as the speed of light was approached. In the meantime small quantities of radium had become available, and as this emitted electrons travelling with velocities very close to that of light it was possible to make an experimental test of these theories. This Kaufmann did in 1902



By courtesy of the Cavendish Laboratory

THE LATE LORD RUTHERFORD

and he got results which were in general agreement with all the theories, to the order of accuracy of the experiment.

* * * *

These experiments attracted very considerable attention and led many people to the unjustified conclusion that, since the mass of the electron appeared to be entirely due to its charge, therefore all mass was nothing but a manifestation of electric charge. On this idea the mass of the hydrogen atom—1850 times that of the electron—was simply explained by supposing that the atom contained 1850 electrons. This stage, however, did not last long. In 1905 Einstein showed, from relativity ideas, that the mass of a body should change with its speed, and that it does not matter whether it is charged or uncharged, the change in mass is just the same. Every body, no matter what it consists of, must obey the Einstein law, and all experiments seem to show that this law is correct. Kaufmann's experiments agreed with the relativity results just as well as with the older electrical theories, so that it was no longer possible to suppose that the mass of the electron was entirely due to its charge. Since the only method of estimating the radius a of the electron was to assume that the mass was due entirely to the charge, and then use the expression given above, it is clear that once more there was no estimate of the size of the electron. It is probable that the radius is of the order 10^{-13} cm. and recently Prof. Born has evolved a theory which leads to a value of this order, but it is early yet to say whether that theory is correct.

We were quite happy for ten or fifteen years with the idea of the electron as a spherical distribution of charge, possibly together with some "ordinary" mass. In 1925, however, in order to explain some of the complications of the spectra of hydrogen and helium, Uhlenbeck and Gousmidt suggested that the electron also had a magnetic moment, and as they realized that a spinning spherical charge would have a moment of this kind they postulated a "spinning electron". Shortly after, in 1930, Dirac developed his general theory in which relativity and wave-mechanics were combined, and he found that he could explain the fine structure in the spectra without postulating a special "spinning electron". At first it looked as though the idea of the "spinning electron" was not correct, but it appears now that Dirac has come to the conclusion that, on his theory, the electron must behave as though it had a magnetic moment, though there is no need to postulate this separately as it could not help behaving like that anyway.

* * * *

It is next of interest to give some account of the determination of the electronic charge e, since this quantity is so intimately connected with the evaluation of atomic magnitudes. The first experiments were made by Townsend in the Cavendish while I was there in 1897. He found that a cloud condensed on hydrogen which had been produced by electrolysis and bubbled through water. This cloud was also found to be charged, and he determined the charge on each droplet in the following way. The weight of the whole cloud was found by precipitating it and weighing on a balance. The average weight of each drop was found by measuring the rate of fall of the cloud and using Stokes' law. Hence the number of drops was known. Since the total charge carried by the cloud could also be measured it was possible to find the charge on each drop. The method did not give a good value for the electronic charge, because many of the drops were multiply charged, but it is interesting because it included practically all the ideas which were later used in accurate measurements of the charge.

In 1908–13 J. J. Thomson used a method in which a cloud was produced by expansion, and its weight estimated from the known expansion ratio. Wilson applied an

electric field so that the charged drops could be held stationary or driven up or down. In 1908 Geiger and I counted the number of α-particles emitted from a certain quantity of radium and then measured the total charge which they carried. We obtained a value $4{\cdot}65 \times 10^{-10}$ e.s.u., considerably greater than the value of $3{\cdot}4 \times 10^{-10}$ deduced by Thomson, but we did not think of our method as being at all accurate. In that connexion Prof. Planck once told me an interesting story. When he first put forward his quantum theory of light, people were slow to believe it, partly because the theory required the electronic charge to be $4{\cdot}7 \times 10^{-10}$, whereas the accepted value was then $3{\cdot}4 \times 10^{-10}$. Planck himself was doubtful because of the discrepancy, but when Geiger and I announced the value $4{\cdot}65 \times 10^{-10}$ he began to be certain that his theory was correct.

The magnitude of the charge was, as you know, measured accurately by Millikan between 1910 and 1917. There is some doubt at the present day as to whether his result is as accurate as was originally believed, but I will not deal with that question here.

* * * *

Now I come to a most interesting discovery of recent times. Many people had thought that in a properly constituted universe there ought to be a certain degree of symmetry, and where we had a negative electron we ought also to have a positive electron of the same small mass. Although this had often been looked for it was not found until 1931, when Anderson, in California, was photographing the tracks of cosmic-ray particles as revealed in a Wilson Cloud chamber. A strong magnetic field was applied to the chamber and he found that some of the tracks were curved in one direction and some in the other, showing that some represented negative particles and some positive. Other evidence showed that the masses of both were small and of the order of the electronic mass. Anderson got photographs showing these tracks only very rarely, but in 1933 Blackett and Occhialini, in the Cavendish Laboratory, developed a method by which the cosmic ray was made to trip the apparatus and "take its own photograph" so to speak. By this method it was possible to get many photographs of the tracks of positive electrons, or "positrons" as they are now called.

* * * *

Blackett interpreted these results in terms of a theory developed in 1931 by Dirac. This theory had suggested that positive electrons might exist, but that their life would be very short since they would combine with the first negative electron they encountered and give rise to energy of radiation. In a sense Dirac had predicted the positive electron before it was discovered, but the prediction was well hidden in the theory. Theory and experiment both indicated that under suitable conditions radiation energy of very short wave-length, such as is present in the cosmic radiation, can disappear and give rise to a pair of electrons, one positive and one negative. This occurs most readily in the intense electric field surrounding a heavy nucleus, and is only possible if the quantum energy of the radiation is greater than one million electron volts, which is the equivalent of the mass of the electron-pair.

We now turn to consider the question of atomic structure. In 1895 Lennard made a famous experiment in which he passed electrons through a thin window in the discharge tube where they were made, and was able to observe them outside the tube. Since the electrons could penetrate the window so easily he concluded that the atoms in the window must have a very open structure and have comparatively large spaces between them. He suggested that the atoms might contain spheres of positive electricity associated somehow with negative charges. A year or two later J. J. Thomson elaborated this idea and calculated how negative electrons would

distribute themselves throughout a sphere of positive charge. He was able to explain in this way the fundamental nature of the periodic table.

* * * *

Now I myself was very interested in the next stage, so I will give you it in some detail, and I would like to use this example to show how you often stumble upon facts by accident. In the early days I had observed the scattering of α-particles and Dr Geiger in my laboratory had examined it in detail. He found that the scattering was usually small, of the order of one degree, in thin pieces of heavy metal. One day Geiger came to me and said, "Don't you think that young Marsden, whom I am training in radioactive methods, ought to begin a small research?" Now I had thought that too, so I said, "Why not let him see if any α-particles can be scattered through a large angle?" I may tell you in confidence that I did not believe that they would be, since we knew that the α-particle was a very fast massive particle, with a great deal of energy, and you could show that if the scattering was due to the accumulated effect of a number of small scatterings the chance of an α-particle's being scattered backwards was very small. Then I remember two or three days later Geiger coming to me in great excitement and saying, "We have been able to get some of the α-particles coming backwards...." It was quite the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you. Now on consideration I realized that this scattering backwards must be the result of a single collision, and when I made calculations I saw that it was impossible to get anything of that order of magnitude unless you took a system in which the greater part of the mass of the atom was concentrated in a minute nucleus. It was then that I had the idea of an atom with a minute massive centre carrying a charge. I worked out mathematically what laws the scattering should obey, and I found that the number of particles scattered through a given angle should be proportional to the thickness of the scattering foil, the square of the nuclear charge, and inversely proportional to the fourth power of the velocity. These deductions were later verified by Geiger and Marsden in a series of beautiful experiments.

Now let us consider what deductions could be made at that stage. By considering how close to the nucleus the α-particles could go, and yet be scattered normally, I could show that the size of the nucleus must be very small. I also estimated the magnitude of the charge and made it about a hundred times as great as the electronic charge, e. It was not possible to make an accurate estimate, but general evidence indicated that the nucleus of hydrogen must have a charge e, helium $2e$, and so on. Geiger and Marsden examined the scattering in different elements and found that the amount of scattering varied as the square of the atomic weight. This result was rough but quite sufficient: it indicated that the charge on a nucleus was roughly proportional to the atomic weight.

* * * *

At this time the idea that charge and atomic numbers were related was prevalent in our Laboratory, and it was then that Moseley began his famous experiments on X-rays. He showed that the X-ray spectra of elements varied regularly and uniformly from one element to the next, the spectra all being similar but shifted in frequency as we pass from element to element. Now, on the nuclear theory, the X-ray spectrum is presumably connected with the movement of electrons very close to the nucleus, and Moseley's experimental results led to the conclusion that the X-ray properties of the elements were dependent on the square of the whole number, which varied by unity from one element to the next. Moseley supposed that the atomic number repre-

sented the charge on the nucleus, and starting with aluminium 13, he was able to explain the X-ray properties of the elements up to gold, and the series was extended right up to uranium in 1932.

This theory at once showed which elements were missing in the periodic table, and where one ought to look to discover new elements. It was now clear that the atomic weight, which the chemist had previously supposed to be the important factor in the periodic table, must be replaced by the atomic number, and the properties of all the elements ought to be explicable in terms of whole numbers. The essential point of the identity of the atomic number and the nuclear charge was experimentally verified by Chadwick after the war.

This nuclear idea at once explained in a general way the existence of isotopes. The nuclear charge controls the arrangement of electrons and this arrangement in turn determines the chemical properties. We should therefore anticipate that isotopes should be bodies with the same nuclear charge but with different nuclear masses. As we know, this has been completely confirmed by Aston's later work.

* * * *

Now we come to that question with which Bohr's name is associated, "How are the electrons arranged in the outer atom?" Bohr's original quantum theory of spectra was one of the most revolutionary, I suppose, that was ever given to science, and I do not know of any theory that has been more successful. He was in Manchester at the time, and, being a firm believer in the nuclear structure of atoms as shown by experiments on scattering, he tried to see how he could arrange the electrons so as to give the known spectra of the atom. His success lay in bringing entirely new ideas into the theory. He imported into the picture the idea of the quantum of action, and he imported also the idea, foreign to classical physics, that an electron might circulate in an orbit round the nucleus without radiating. I was perfectly aware when I put forward the theory of the nuclear atom that according to classical theory the electrons ought to fall into the nucleus, but Bohr postulated that, for some unknown reason, they did not do so, and with this idea he was able, as you know, to give an explanation of the origin of spectra. He then passed from stage to stage, making certain reasonable assumptions, to work out the distribution of the electrons in all the atoms of the periodic table. There were many complications, since the distribution had to agree with the optical and the X-ray spectra of the elements, but in the end he was able to suggest an arrangement of electrons which showed the meaning of the periodic law.

* * * *

As a result of later developments, largely influenced by Bohr himself, and developments by Heisenberg, Schroedinger and Dirac, the whole mathematical theory has changed, and the idea of wave-mechanics has been introduced. Quite apart from these later developments I consider the work of Bohr to be one of the greatest triumphs of the human mind. To realize the significance of his work you have only to consider the incredible complexity of the spectra of the elements and to think that within ten years all the main features of these spectra had been understood, so that now the theory of optical spectra is believed to be so completely settled that many people consider it a dead subject, as sound was some years ago.

We must now pass to the development of later ideas on the structure of the nucleus itself. In 1919 I showed that when light atoms were bombarded by α-particles they could be broken up with the emission of a proton, or hydrogen nucleus. We therefore presumed that a proton must be one of the units of which the nucleus of other atoms was composed, and the theoreticians set to work to try and explain the properties of

nuclei by combination of protons and negative electrons. It is, however, very difficult to combine the slow and ponderous proton with the light and lively electron in such a confined space as a nucleus, and it was not until Chadwick brought to light the existence of an uncharged particle, the neutron, that the problem appeared theoretically soluble. It was then possible to suppose that the nuclei of all atoms consisted of a combination of protons and neutrons, so that for example oxygen with charge 8 and mass 16 had 8 protons and 8 neutrons. This was a very simple idea, and the valuable point was that the constituent particles had similar mass. But what are we going to do about the fact that a negative electron often comes out of a nucleus in radioactive changes, and that a positive electron comes out in certain artificial transmutations? In answer to this the theoretician suggests that, in the confined space of the nucleus, where the force between the particles is enormous, protons may change into neutrons and vice versa. For example, if a neutron lost a negative electron it would pass into a proton, and if a proton lost a positive electron it would become a neutron, so that in the first case a negative particle, and in the second a positive particle, could be emitted. The electrons and positrons do not exist free in the nucleus, they are bound to the neutron or the proton as the case may be, and they are only released under certain conditions of great energy changes within the nucleus.

I have tried to give you a general idea of the way in which we started to investigate these matters forty years ago, and of the way in which the ideas have developed stage by stage. I have also tried to show you that it is not in the nature of things for any one man to make a sudden violent discovery; science goes step by step, and every man depends on the work of his predecessors. When you hear of a sudden unexpected discovery—a bolt from the blue as it were—you can always be sure that it has grown up by the influence of one man on another, and it is this mutual influence which makes the enormous possibility of scientific advance. Scientists are not dependent on the ideas of a single man, but on the combined wisdom of thousands of men, all thinking of the same problem, and each doing his little bit to add to the great structure of knowledge which is gradually being erected.

Hawaiian Hula Dance

By Clifford Gessler

(Clifford Gessler gives us a description of one of the most picturesque of Polynesian customs.)

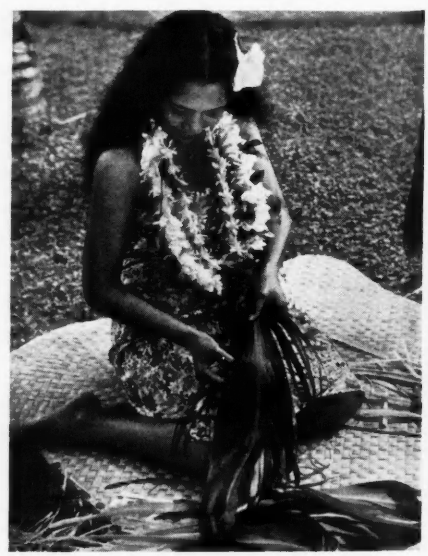
WHEN Hawaiian "hula" girls dance in raffia skirts it is as a concession to visitors' ideas of what Hawaiian costume should be, rather than a custom. The straw skirt conforms to the popular fallacy, but the authentic art of the hula dance requires a garment of living green. To the conscientious performer of those inimitable torso twists and hip rotations the hula is a serious matter, bound up with customs and traditions so ancient that their origin has been forgotten, but in many of its forms it was originally a sacred dance. Its performers underwent long and arduous training, surrounded by strict customs and purified by solemn rites. Later the hula was used as an artistic portrayal of aspects of nature or of history, or a glorification of a locality or person. In all these cases the sacred element to some extent remained, for the chiefs in whose honour the dances were performed were thought to be divine, and spirits dwelt in all things. Early voyagers described dances by as many as two hundred girls at one time to the thud of gourd drums and the clash of rattles and

Fluttering fingers depict the fall of rain, the dance of waves, the wind-blown leaves, the opening of flowers

the swish of split stalks of bamboo—two hundred bronze bodies undulating beneath the delicate petals of island flowers and skirts of cool green leaves.

Nowadays the first step in preparation for a hula is a trip to the woods to gather the leaves. There are plenty of them, for the *ti* (pronounced *tee*) is a vigorous plant, and the leaves are long and fairly wide. They are worn only while still fresh and green. When withered, they are thrown away and a new skirt is made.

Selecting the longest leaves, the dancer strips the spiny mid-rib from each of them, using the old biting method. Then she shaves the stem of the leaf down to make it flexible, so that it can be tied more easily to the belt, which is made from any fibre material. A manufactured cord will do, but a strand of bark of the *hau* tree, a kind of hibiscus, is favoured. She splits the leaves into narrow ribbons to make them more flexible and to give the desired swish, then knots the stems around the belt. On very special occasions a wrap of tapa is worn under the leaves, but as scarcely any tapa is made in the islands now, it is more convenient to compromise with a brilliantly coloured one-piece dress as the under garment. Some of the more conservative prefer a two-piece outfit, with a blouse of yellow cloth, giving much the same effect as the sacred yellow tapa of ancient days, and always they wear flowers.

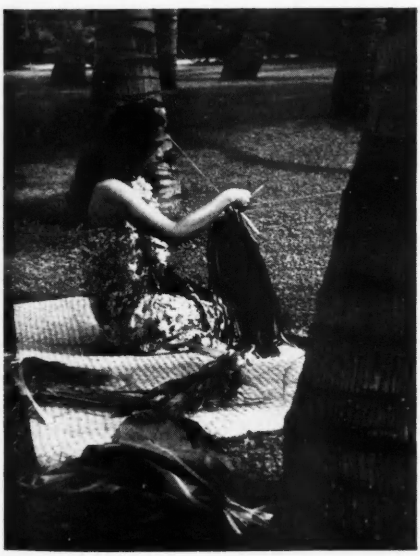


Legs and arms are bare, for gestures are as much a part of the dance as the movements of the body. It is thus that, in the words of one of its modern exponents, the hula takes its rightful place as "a co-ordination of poetry, music, and of pantomime". Fluttering fingers depict the fall of rain, the dance of waves, the wind-blown leaves, the opening of flowers. Attitudes of feet, legs, hands, and even movements of the eyes,

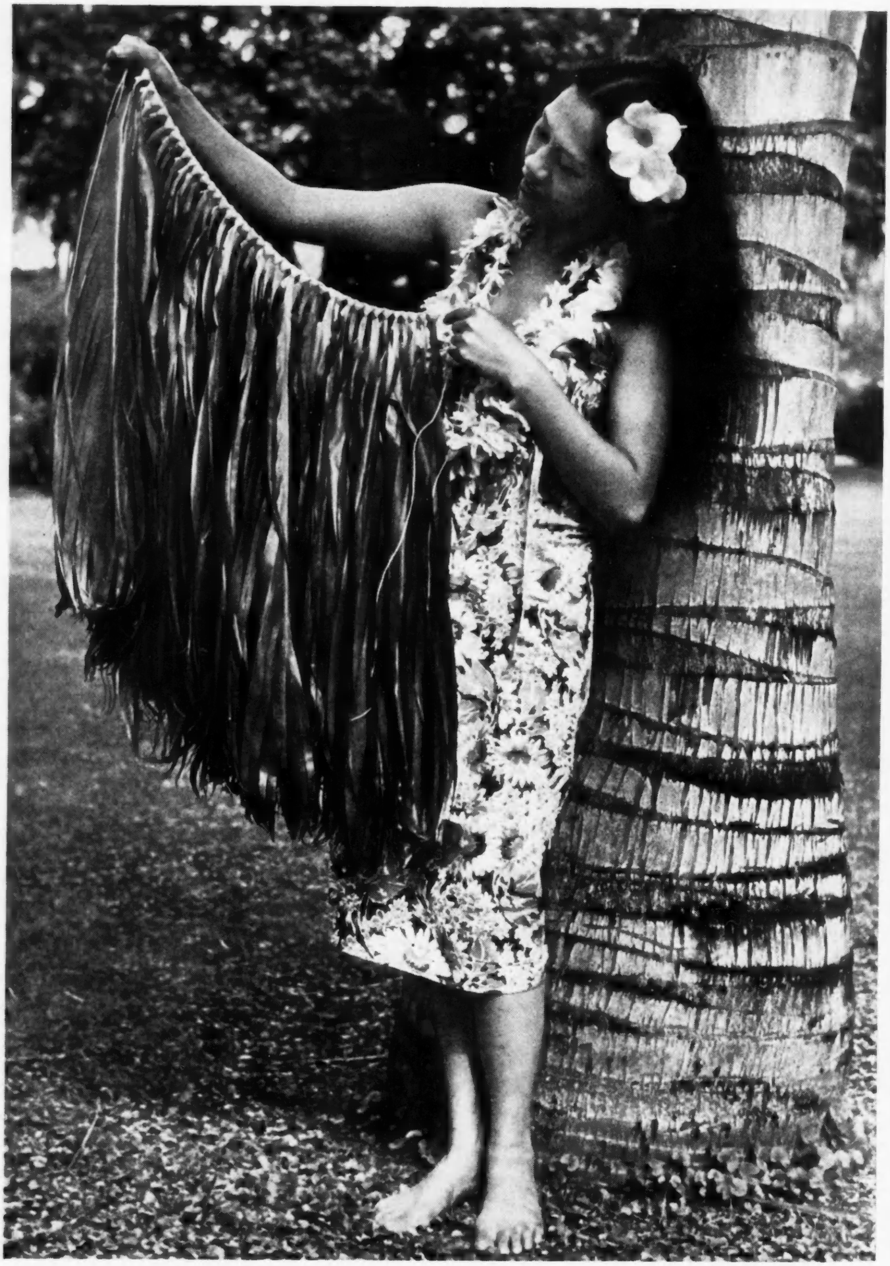
are made to harmonize with those of the rest of the body.

Hundreds of different hulas were known to the Hawaiians of Captain Cook's time. Many have been lost, but a present-day authority lists about twenty that survive, though some of these are rare. They cover a wide range. Some are danced in a standing posture, others sitting, others kneeling. Some are accompanied by large gourd drums, others by a drum made of a hollow log covered with sharkskin, others again by rattles or by sticks of split bamboo or by bars of hard wood clashed together rhythmically by the dancers.

Some curious dances, now known only by a few very old people, represent animals, such as the pig and the dog. A very stately and colourful one tells the unhappy love story of the volcano goddess Pele. One represents the creation of the world. Another recounts the voyages of ancestral navigators who sailed the Pacific in great double canoes, visiting distant lands. One of the most widely known describes in word and gesture—for all these dances are accompanied by chants or songs—the beauty of Liliuokalani, beloved last queen of the islands. Then there is the dance which shows in pantomime a quaint story of King Kalakaua and of a woodland tryst that was broken, leaving His Majesty disconsolate in the rain. "Presumptuous is the rain of Nuuanu" protests, in the song, the disappointed king.



Hula movements have been classified scientifically into six basic steps, culminating in the significant figure "around the island", but each may be described as a "fluent gesturing coil of curves across bewilderment of planes", an instinctive expression, disciplined by training; the language of the body interpreting the aspirations of the spirit.



The finished skirt of fresh green ti leaves

Rickets and Vitamin D

By Ernest Baldwin

(Dr Baldwin wrote on "How Water can kill Fishes" in the April number of "Discovery".)

As few as fifty years ago rickets was almost universal among the children of our larger cities. The protruding forehead, bowed legs and swollen joints of ricketty children were too common to excite attention except from a handful of physicians. Although the disease had been carefully described as early as 1650 by Francis Glisson, very little was known about its cause or cure until relatively recently. Perhaps the fundamental observation on the subject was that rickets—known to this day as "the English disease" on the continent—is particularly prevalent in those communities which see little of the sun.

The importance of sunlight in the prevention and cure of rickets was first realized at the end of the last century, but another remedy has been known longer even than anyone can say, namely cod-liver oil. Although Eskimos, for instance, see no sunlight at all for six months of the year, they seldom show any signs of rickets because their diet ordinarily includes large amounts of fish oils, quantities larger indeed than the average Englishman could even contemplate without feeling decidedly bilious!

Yet in spite of the knowledge that either sunlight or cod-liver oil is capable of curing rickets, an examination of 1600 L.C.C. school children carried out as recently as 1928 revealed the fact that almost 1400 of them had some degree of rickets. What, then, is the cause of rickets? How can it best be cured, or better, prevented?

One of Science's Contributions to Mankind

At the present time, when wars and rumours of wars bulk so large in the daily press, science is not infrequently accused of having done more harm than good to mankind. But in one branch at least, that of nutrition, modern science has contributed incomparably more to the welfare than to the destruction of humanity. About the beginning of this century it began to be clear, as the result of large numbers of feeding experiments upon animals, that food must contain small quantities of certain chemical substances known to-day as vitamins if it is to produce adequate growth and maintain the body in vigorous health. Such was the case with rickets. In the absence of one of these vitamins, vitamin D, rickets makes its appearance. At the present time we know precisely what vitamin D is, and exactly how much of it is required to prevent or to cure rickets. To-day no child need have rickets, thanks to this knowledge. But a long and difficult path had to be travelled before this valuable knowledge could be found.

Here was the case of a disease which could be cured by (*a*) sunlight, or (*b*) the right kind of food—a good field for controversy, and one which could only be explored by means of experiments upon animals, so that those scientific workers who endeavoured to discover the truth about it were exposed, and for that matter still are exposed, to the calumny and the bitter attacks of the antivivisectionist groups. But scientific research, and especially research such as this, which is of the utmost benefit and value to mankind, is accustomed to difficulties, and so the work went on.

The Necessity of Studying Animals

There were at the very start two main problems: first, how does a ricketty individual differ from a normal one, and

secondly, by what means can the disease be prevented and cured? To begin with it was necessary to find a way of producing rickets in animals, for as the bent limbs and swollen joints of the victims suggest, this is a disease which particularly affects the bones. To study the bones of human cases was clearly out of the question, but it was found easy to induce rickets to appear in experimental animals simply by feeding them on a somewhat restricted diet. This diet, which the antivivisectionists brand as "unnatural", is, if anything, rather better than that on which many human beings are obliged, for economic reasons, to live at the present time.

Rickets, as has been said, is particularly a disease of the bones. Instead of being hard, rigid structures, the bones of a rachitic animal are soft and less limy than normal, so that they bend under the weight of the body and become distorted. The substances necessary to mineralize and strengthen the bones are none other than calcium and phosphorus, substances which every gardener knows to be essential for the proper growth even of vegetables. Calcium and phosphorus are both to be found in milk, and it might therefore be thought that children are not likely to get rickets so long as they are fed on milk. Actually this is far from being the case. Mineral substances alone are not enough, for, as we now know, they cannot be made use of by the body unless vitamin D is also given to the animal. Milk, although it contains considerable amounts of minerals, does not as a rule contain much of the vitamin, and this has therefore to be supplied from other sources if rickets is to be avoided.

Smoke cuts off the Actinic Rays

So, then, the problem became that of finding out what vitamin D is, and how it is produced. Following up the discovery that exposure of ricketty animals to sunlight can effect a cure, the German physician, Huldschinsky, tried the effect of different kinds of light and found that ultra-violet alone is effective. This, of course, explains why it is that rickets is especially prevalent in smoke-curtained towns such as London and Manchester; for smoke, while allowing the rest of the sun's radiations to pass through fairly completely, almost entirely stops the passage of the ultra-violet. Shortly after Huldschinsky's discovery it was found that rickets could also be prevented if the animal's food was irradiated with ultra-violet light, and it thus became clear that there must be in the food something which is turned into the precious vitamin by the action of ultra-violet light, and which might be called a "pro-vitamin". The next step consisted in trying to find out exactly which constituents of ordinary foods are capable of undergoing this transformation. Attention was soon focused on a substance called cholesterol, which occurs in small amounts in a great variety of food materials, for when samples of this substance were irradiated they were found to develop powerful antirachitic properties. It thus seemed that cholesterol was itself the pro-vitamin which was being sought.

Natural and Artificial Vitamins

But presently it was discovered that the cholesterol itself contained traces of an impurity and that this, and not cholesterol itself, is the real pro-vitamin. This impurity appeared to be a substance rather similar to cholesterol, called ergosterol, a compound which can be fairly easily prepared from plants. Specimens of ergosterol were then irradiated, and from them the first samples of pure vitamin D were prepared, and christened calciferol. Minute amounts of calciferol will cure the most stubborn cases of rickets.

It has since been found that the natural vitamin, which is referred to as vitamin D_3, and is present in cod- and halibut-liver oils, is not quite the same thing as calciferol, but the "artificial" substance calciferol is actually rather more powerful than the natural D_3 substance. Both vitamin D_3 and its synthetic counterpart calciferol are

effective preventive and curative agents for rickets, and by their aid we can control the onset of rickets in animal and human cases alike. There is no longer any reason why anyone, animal or human, should suffer from this disfiguring malady which has crippled and even killed so many human beings in past ages. The benefits to be derived from the discovery, isolation and artificial manufacture of vitamin D are manifold, and they do not end with the prevention and cure of rickets.

The Mother's Need for Minerals

Young children naturally require large amounts of mineral substances, and therefore generous allowances of vitamin D, for their bones have to grow and become properly mineralized. But although young children are most likely to show the symptoms of rickets, the brunt of the burden falls upon the mothers, for it is from them, both before birth and during the period of suckling, that the infants must obtain their supplies of mineral substances. This imposes a great drain upon the mineral resources of the mother; unless she is well supplied with mineral substances and enough vitamin D to enable her to make use of them, she is liable to lose more calcium and phosphorus than she can spare. In certain parts of the world the women are obliged by social or religious customs to stay indoors, and the consequent lack of sunlight, together with poor food, often leads to a very serious condition known as osteomalacia in pregnant and nursing mothers. Suffering at the very outset from deficiency of both minerals and vitamin D, these women's bones undergo demineralization in order that the child's requirements shall be met, and the bones, especially those of the hips and the legs, become softened and hideously deformed.

Teeth and Vitamin D

But the bones are not the only parts of the body which require calcium and phosphorus in order to function properly. The teeth also consist largely of these substances, and most of the dental troubles of this world are due to improper or incomplete mineralization. Rickets and bad teeth almost invariably go together. Expectant and nursing mothers in this country probably never suffer from osteomalacia, but those who are short of vitamin D and the necessary minerals lose some or all of their teeth, and the children in their turn usually have defective teeth, with subsequent misery, inefficiency, indigestion and what else besides. All expectant mothers ought therefore to be provided with enough mineral substances, preferably in the form of milk, and with vitamin D in amounts large enough to allow them to make proper use of the minerals. If ever the State decides to pay for these provisions it will reap a rich reward in the greater contentment, health and general efficiency of the next generation.

One more case, and a serious one, may be mentioned in order to show how far reaching are the effects of mineral deficiency. When such a deficiency exists there is naturally a tendency for the blood to contain less calcium than usual, and this results in extreme irritability of the nerves, leading to convulsions, which are often fatal. This condition, which is known as tetany, is not uncommon in ricketty infants, and fortunately it can be relieved in any of a number of ways. But only one treatment can give a lasting cure, namely the administration of calcium and phosphorus, together with vitamin D.

Minerals and Vitamin D

In case it appears in what has been said above that there is some confusion between the importance of mineral substances on the one hand and that of the vitamin on the other, perhaps it will be well to explain once again the part which the vitamin plays. The disorders which result from vitamin D deficiency are due in reality to deficiency of mineral substances and cannot be cured unless this deficiency is made good. But to feed calcium and phosphorus to a ricketty

patient will not cure the disease, *for these substances cannot be utilized unless vitamin D is also available*. This may be obtained in the food, or may be formed from certain constituents of the food by exposing either the patient or the food to ultra-violet light. Under these conditions, but not otherwise, the mineral substances can be absorbed into the blood and can then be carried by it to the parts of the body in which they are needed. These parts are, in particular, the bones and the teeth, and here the mineral materials can be laid down to form firm, strong bones, capable of supporting the weight of the body, and hard, sound teeth which will be relatively impervious to decay.

Warning

In conclusion a word of warning must be added, for it is possible to have too much of the vitamin. If excessive doses are taken there arises the possibility of overloading the body with mineral substances. The bones may become over-mineralized and brittle, the teeth may become cemented into an almost solid block with the jawbones, and minerals may even be deposited in wrong places. This may lead to hardening of the arteries on the one hand, and even to serious damage to the kidneys. Probably none of us is likely to develop any of these "excess disorders" so long as we take our minerals in the form of milk and our vitamin D in the form of cod- or halibut-liver oil. But nowadays it is very easy to buy highly concentrated preparations of the synthetic vitamin, calciferol, in combination with calcium, and to those who make indiscriminate use of such preparations let this be a warning—consult your doctor first! Excess in this case is at least as dangerous as deficiency.

The British Association at Cambridge

THE British Association is meeting in Cambridge in August. An account of its proceedings will be included in the September and October numbers of *Discovery*. It is worth recalling the extraordinarily valuable missionary work that the B.A. performed in the nineteenth century and down to the war. At that time, science was still an uneasy intruder in the national life; it was necessary to find some means of spreading its aims, methods, triumphs and potentialities. This function the B.A. magnificently fulfilled, and to-day the battle has been very largely won. (It is only fifty years ago that the Master of a Cambridge College, contemplating the election of a scientific fellow, said: "Elect —? I am positive it would be unwise to elect —. He wants to do science, doesn't he? Well, I very much doubt whether science will *last*.")

Nowadays the B.A. is finding other fields, and it is significant that many of its discussions are concentrating upon the influence of science on social life.

Notes of the Month

The Invention of the Bow

WHEN was the bow invented? Next to the discovery of how to make fire at will, the application of mechanical force to the propulsion of a projectile weapon by means of the bow, vastly increasing man's range of power and, therefore, of his food supply, is the most important step in early progress towards civilization.

Yet authorities are not agreed as to when this weapon was first invented. It used to be held that it was not introduced before the New Stone Age, and that it was, with the domestication of animals and the introduction of agriculture, one of the innovations brought to European civilization by neolithic man.

Some of the paintings in the caves inhabited by palaeolithic man in the south of France show bulls and other animals with barbed weapons piercing their flanks; but these are now generally considered to be not arrows, but dart-like weapons in the nature of an assegai. A palaeolithic relief carving on the face of a rock at Laussel in France is of a male figure with the arms in the position of a bowman, who has just released an arrow. It has, therefore, been named "the Archer"; but this interpretation is by no means certain.

When the rock- and cave-paintings of Stone Age man in eastern Spain were discovered some thirty years ago, it was seen that among them were representations of men fighting and hunting with the bow and arrow. It was then held that these paintings had been made by a people who entered Spain from North Africa and were rather later in date than the peoples of the Old Stone Age, who had produced the cave-paintings of northern Spain and the south of France. Further examination of these paintings by many archaeologists has led them to confirm the conclusion that they belong to the Mesolithic period, that epoch of the Stone Age which intervenes at the close of the Ice Age between the cultures of the Old and the New Stone Ages.

Now, however, strong arguments have been put forward, in the light of fresh evidence, by Prof. Hugo Obermaier, professor of archaeology in the University of Madrid, to show that the paintings of the East Spanish school of art are very much older than has been thought. He maintains that they really belong to the palaeolithic period, being of the same age as the paintings of northern Spain and quite as old as many of the paintings of the French caves.

Prof. Obermaier bases his opinion firstly on the style of the paintings. This, he says, is identical in both the north and the east of Spain. The chief, in fact, almost the only, difference between the two schools is that the human form, singly and in groups, appears frequently in east Spain, but only rarely, and usually then in some ceremonial dress as of a priest or magician, in both northern Spain and in France.

Secondly he points out that the animals represented in both areas are the same, except that in the more southerly region, the animals belonging to a cold climate, such as the mammoth, are not represented; but the various kinds of deer, antelope, bulls, etc., belonging to the temperate species of the late Pleistocene geological epoch in France, are all found in the Spanish paintings of both schools.

The most cogent argument, however, which Prof. Obermaier brings forward, is based on the evidence from a recently excavated cave in Valencia. Here in undisturbed soil, which shows its dating by an undisturbed stratification of the deposits, were found plaques of calcareous limestone, on which were engraved figures of animals identical in style and execution with those of the paintings and drawings of the eastern Spanish school, and, therefore, probably of the same age. As these plaques can be dated as belonging to the Solutrean and proto-Solutrean, that is they are of an age belonging to the later phases of the Old Stone Age, they are at least as old as the paintings of northern Spain, and some of the later paintings of southern France.

If Prof. Obermaier's contention withstands further investigation, the art of eastern Spain affords incontestable evidence that the bow had already been invented by palaeolithic man.

E. N. FALLAIZE

Spelling Mistakes

In the course of an investigation of inherited factors carried out at the Vienna Psychiatric Clinic, Dr Gottfried von Engerth found a certain peculiar type of orthographic mistake which is actually inherited. Engerth observed and analysed two gifted families of a high degree of intelligence and education in which mistakes in spelling might consequently not be expected. Yet mistakes existed, and they could be traced in letters and other documents of the families in question back to the middle of the nineteenth century. To go further back would have been useless, as spelling earlier than this was not standardized.

In one of the two families, consisting of 83 grown-up members, 21 have the orthographic defect, that is, they have certain characteristics; each has a strong musical vein, and each hears the words in a different way from that in which they are written. The mistake therefore originates from the fact that they are unable to free themselves from the sound of the word. Some of these individuals possess the property of "hearing colours", which means that certain sounds are associated for them with certain colours, and the tint they see when a word is pronounced differs from that of the written word. This explains the unconscious resistance they oppose to "correct spelling".

In the other family the spelling defect appears to be connected with other physical peculiarities, "eidetic disposition". Consequently, the excuse that orthographic mistakes are handed down, can be applied to certain cases only.

(*From* G. RABEL, *Vienna*)

On the Stability of the Latent Photographic Picture

When a photographic plate has been first exposed to daylight or violet light and thereafter to red rays, the effect of the previous exposure is annulled and the plate is as if it had never been exposed. This phenomenon was discovered by Sir William Herschel and is known as the Herschel effect. Recently, F. Urbach and A. Wolinsky found in the Vienna Institute for Radium Research, under Professor Stephan Meyer, that the neutralization effect is strongest if applied immediately after the primary exposure. The later the application, the less powerful the effect. This diminution is noticeable even after a lapse of twenty hours. That means that the latent photographic picture is unstable at first and can be easily destroyed, and that it becomes more and more stable with increasing time.

(*From* G. RABEL, *Vienna*)

Viruses: A Clarification

Our note on viruses in the June issue may have given a misleading impression. The first person to isolate the virus of tobacco mosaic in a pure and semi-crystalline form was Dr W. M. Stanley of the Rockefeller Institute in Princeton, N.J. To F. C. Bawden and N. W. Pirie there fell the distinction, some time later, of producing the first true crystals of a virus.

Nutrition and Health

I. The History of Nutrition

By C. H. MARCH

"WHAT'S the use of bothering about this nutrition business? It's only another fad."

How often has this remark been made? It illustrates one of the difficulties facing a nutritionist attempting to lead the populace along the straight and narrow path of proper nutrition.

The general public may as a rule be divided into two groups; the first is hyper-susceptible to suggestion and will run to extremes with any new diet fad that crops up; the second is scornful of any attempt to interfere with its dietary regimen. There are of course a goodly number of intermediaries who try to tread the middle course, but even among these there are many who have entirely irrational food fads.

Unfortunately for nutrition and dietetics there is no other subject in which there are so many fads and cults; with the result that the true nature of our study of the subject is clouded with mis-statements and exaggerated claims. In this little series of articles I hope to put before you the general principles of nutrition and dietetics as approved by the world's leading experts.

"What exactly is nutrition?" you will ask. Well, nutrition might be described as the process of eating and absorbing those foods which supply you with the best nourishment. Foods vary considerably in the amount and type of nourishment they supply, for there is more than one type of nourishment.

Have you ever stopped to consider how much food you eat in a year? Most of us consume about 1500 lb. or $\frac{3}{4}$ of a ton of food in this time. A family of four will deal with $2\frac{1}{2}$–3 tons of food per year.

Only from your food can you obtain the substances which are going to make you grow, replace worn-out tissues, enable you to do housework, play tennis or perform any movement at all. Most of us are particularly careful what sort of petrol we put in our cars—we like the best grade; we think our car lasts longer if we use the best petrol. What about ourselves? Our racehorse owner or trainer watches the feeding of his horse with religious care—his horse must have only the best food, but he himself may eat anything. Our farmers are delighted to see their stock in good condition; they see that the animals have everything they need in the way of food. If the average man exercised the same care over his own diet as he does with his animals he would be a good deal better off.

You should rid your minds of old ideas of diet and nutrition. You do not have, for example, to become a vegetarian to become nutrition-conscious. Vegetarianism has much in its favour but like all movements of its kind it goes too far. Probably the best example of the superiority of the mixed diet over the purely vegetable diet is given by two tribes in Africa, the Kikuyu and the Masai. These tribes have lived side by side for many generations; the Kikuyu have existed almost entirely on vegetable food, consuming practically no milk, whereas the Masai have lived on the milk, blood and flesh of domestic animals. These two tribes that have lived in an identical fashion, except for their diet, for so many generations show marked differences in physique. The Masai are taller, stronger, and considerably more active than their vegetarian neighbours.

Before we deal with the elements that you need for proper nutrition, let me tell you something about the history of nutrition. In the early days of our civilization, man lived precariously like a wild animal. Seeds, fruits and roots with occasional fish, small animals and perhaps honey and eggs were his chief foods. At first he consumed all his food in the raw condition and then later began to cook it. In the next stage, man became agricultural and began to till the soil and keep animals. For the winter months he used to salt or dry his meat and store grain.

The famous mathematician, Pythagoras, founded vegetarianism in the sixth century before Christ. Dietetics began to receive some attention from the Greek medical men about the fourth and third centuries B.C. The famous doctor and philosopher Galen in A.D. 150 published a treatise on food which included 71 chapters on fruit and vegetables.

In England, during the Middle Ages, most of the food in winter was composed of grain and salted or dried meat, with the result that nearly everyone suffered

from the disease scurvy, due to lack of vitamin C. This disease was so common in London during these times that it was often called the "London disease". The custom of eating salads was not introduced into England until the time of Henry VIII, when one of his wives, Katharine of Aragon, brought this continental habit with her. Since the idea of growing salad vegetables was completely unknown in England at this time, Katharine had to import a Dutch gardener to cultivate them for her.

Sir Walter Raleigh is believed to have introduced the potato to England, but these tubers were looked upon only as pig food for many years and it was centuries before they came into popular use. The Portuguese first introduced oranges to the Mediterranean countries in the sixteenth century and this fruit soon found its way to England. During the seventeenth century root crops like the turnip began to be planted in England and from then on until the middle of the nineteenth century the quality of the food eaten in England was probably the best it has ever been. Most of the food was eaten fresh. Wholemeal bread was the rule; there was plenty of fresh meat, plenty of potatoes, fresh vegetables and fruit. Sugar was almost unknown. Our ancestors in those days had good teeth. There was no pyorrhoea, no decay.

In 1870 machine milling was introduced and the vital part of the wheat was removed. The outside husk of the wheat and the wheat germ were brushed away and white refined flour became fashionable. The growing of sugar beet in Germany and the consequent increase in sugar production caused the consumption of this commodity to leap up to heights hitherto undreamt of. The tendency to refine and further refine our foods is making the balanced diet a very difficult problem.

To obtain proper nutrition these days an individual has to make a conscious effort to balance his diet. That it is necessary to eat the right foods is shown by the fact that malnutrition can occur if the correct foods are not eaten. A diet of wholemeal bread and butter, milk, and preserved meat will supply you with nearly everything you want for growth and energy. But if you live very long on these articles of diet alone, you will find your joints getting sore, your gums starting to bleed and your teeth getting loose in their sockets. You may think you have caught some disease—and so you have, but it is not a disease due to a microbe; it is a disease due to a deficiency of vitamin C in your diet—in other words—scurvy. Suppose you add an occasional potato to the diet mentioned above, you would probably find that all your troubles except soreness about the gums have disappeared. You may be still suffering from a mild form of scurvy but no one would call it by that name. If, at this stage, you were to take a glass of orange juice each day you would probably find that your gums became firm and strong again. You had balanced your diet. That is just one example. If you were to omit milk from your diet you would get another series of symptoms; the omission of wholemeal bread would cause another series and so on.

The Discovery of James Boswell

By S. C. Roberts

THE library cannot, perhaps, vie with the laboratory as the scene of the major thrills of invention and discovery. On the other hand, it is a profound mistake to assume that literary critics spend their time merely in contradicting each other's judgments or that nothing now remains to be discovered about the writers and the writings of past centuries.

Few authors have been so gradually and yet so dramatically discovered as James Boswell. His *magnum opus*, *The Life of Samuel Johnson*, was published in 1791; it had a rapid sale and by 1822 had reached its ninth edition. It had indeed gained admission to the category of books which no gentleman's library could be without. One result of this was that in 1831 John Wilson Croker produced an extensively annotated edition in which he altered and elaborated Boswell's text in a wholly unjustifiable way. Macaulay, who hated Croker "more than cold boiled veal", seized his opportunity and in his famous essay in the *Edinburgh Review* not only stabbed his enemy viciously, but gave the bayonet many a twist to make the wound incurable. Having dealt thus faithfully with Croker, Macaulay proceeded to pass judgment on Boswell himself, and by one of the ironies of literary history it was Boswell's reputation that suffered most at Macaulay's hands. Macaulay admitted, of course, that the *Life of Johnson* was the finest in the annals of biography; but Boswell himself was "vile and impertinent, shallow and pedantic, a bigot and a sot". How then did he attain literary eminence? By reason, says Macaulay, of his weaknesses: "If he had not been a great fool, he would never have been a great writer." This "inspired idiot" theory has by this time been thoroughly exploded, but such was Macaulay's dominance that it held the field for half a century or more; and while everyone continued to agree that the *Life of Johnson* was the greatest of all *Lives*, no one worried overmuch about its author.

Boswell had died in 1795 and in his will left his manuscripts to his three friends, Sir William Forbes, W. J. Temple and Edmund Malone with "a discretionary power to publish more or less". Forbes and Malone discussed the question but decided to "do nothing at present"; James Boswell the younger died in 1822 and a few manuscripts and proof-sheets belonging to his father were sold with his library; it was then believed, and for more than 100 years continued to be believed, that the great mass of the Boswell papers had been destroyed.

Round about 1840 a certain Major Stone was making a few purchases in the shop of Madame Noel at Boulogne. Observing that the paper in which his purchases were wrapped was the fragment of an English letter, he made enquiries and found

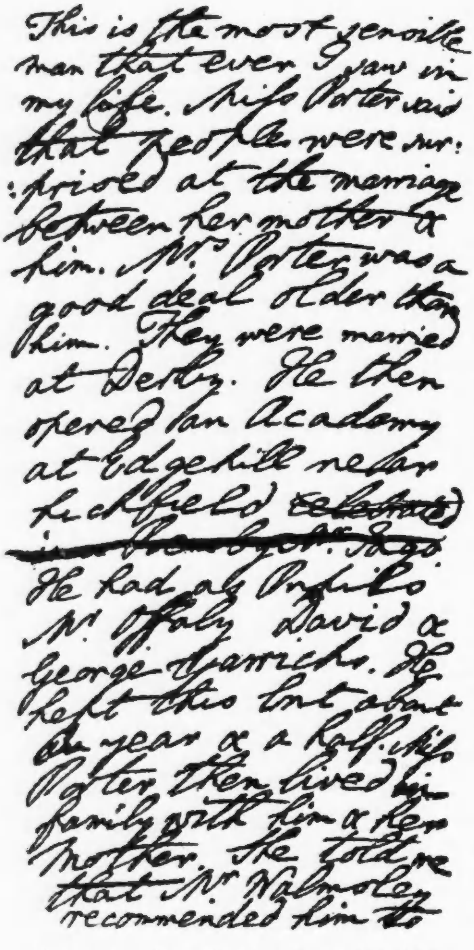
that Madame was using a whole bundle of such letters as useful wrapping-paper. Major Stone bought the bundle, which was found to contain about 100 letters written by Boswell to his friend W. J. Temple (great-grandfather of the present Archbishop of York). The letters were published in 1856 and for many years formed one of the most important sources of information about the life, the habits and the character of James Boswell.

James Boswell

Of the small collection of manuscripts dispersed at the sale of the younger Boswell's library, a few came into the hands of collectors and were subsequently printed; among these were *Boswelliana*, a scrap-book which came into the possession of Lord Houghton; a certain number of proof-sheets of the *Life* and Boswell's Note-Book of 1776–77 which were eventually secured by Mr R. B. Adam. This last little book, which contains Boswell's notes on Johnson's early life, was published in 1925 and even at that date it was still believed that this note-book was one of the very few fragments of Boswell's archives which had escaped destruction. Then, in the following year (1926) rumours began to circulate in Johnsonian circles. The Boswell manuscripts, it was said, had not, after all, been destroyed, but were reposing in Malahide Castle, Co. Dublin, the home of Lord Talbot de Malahide, a great-great-grandson, on his mother's side, of James Boswell.

Through the kindness of the late Dr Bernard, then Provost of Trinity College, Dublin, I was enabled to visit Malahide at the end of June 1926. There, laid out on a table, were samples of the newly discovered manuscripts, a letter from Goldsmith to Boswell, Boswell's notes on his interview with George III, and other delectable documents—samples only, but enough to show that the collection was beyond the dreams of literary avarice. In 1927 the whole of this Malahide treasure was purchased by Lt.-Col. Ralph Isham and the printing of these documents in a limited edition has now been nearly completed. But this was not the end of the Malahide discoveries. In a dusty cupboard in the castle was an ancient croquet-box. Some years after the sale of the main collection this box was opened. It

contained not mallets and hoops, but the manuscript of *A Journal of a Tour to the Hebrides*.


This is the most sensible man that ever I saw in my life. Miss Porter said that people were sur:prised at the marriage between her mother & him. Mrs Porter was a good deal older than him. They were married at Derby. He then opened an Academy at Edgehill near Lichfield ~~[illegible]~~ He had as Pupils Mr Offaly David & George Garricks. He left this but about a year & a half. Miss Porter then lived in family with him & her mother. She told me that Mr Walmsley recommended him to

A page from Boswell's Note-Book of 1776–77, *containing notes on Johnson's early life*

Here, indeed, was God's plenty, but the end was not yet. In 1930 Prof. C. C. Abbott of Aberdeen visited Fettercairn House in search of material relating to James Beattie whose life had been written by Sir William Forbes. Now this Sir William Forbes was the Forbes who had been entrusted with Boswell's manuscripts and Prof. Abbott quickly realized that he might find something more interesting than the manuscripts of the *Life of Beattie*. Boxes and packets of documents were laid out for his inspection. At the bottom of one pile was a bundle bearing the legend "My Journal"—the handwriting was James Boswell's. Another chest contained packets marked "Letters from Mr Boswell"; in another were wads of letters from Dr Johnson; in a sack in an attic was a collection of letters to Boswell and another portion of his Journal—the whole collection amounting to some 1600 documents in all.

Such, in the briefest outline, is the astonishing history of the "curious archives" which James Boswell treasured in his famous Ebony Cabinet at Auchinleck. Boswell, the biographer, leapt immediately into fame; it has taken nearly 150 years to discover Boswell the man.

"Mosquito Day"

By R. L. Mégroz

(Mr Mégroz explains the importance of 20 *August, celebrated by the late Sir Ronald Ross as "Mosquito Day".)*

ALTHOUGH millions of lives have been saved because of the discovery Sir Ronald Ross made on 20 August, 1897, not the least important aspect of the anniversary lies in the fact that owing to so-called "economy", sometimes to mere prejudice, and even to dull indifference, it remains true that, as he complained not long before his death in 1932, less than a tenth of the necessary hygienic measures against malaria have been carried out by the responsible authorities.

Ross was a Surgeon in the Indian Medical Service, whose leisure up to 1895 had been largely spent in writing poetry and fiction, and one of his novels still in print—*The Child of Ocean*—is a sufficient indication that he might have become one of our leading literary figures of the past half century. As is shown by several of his earlier poems, he had been deeply impressed by the amount of disease and poverty in India, and had observed how the prevalence of fevers largely accounted for this. As a doctor he realized how little the medical service armed with the only known prophylactic—quinine, and that necessarily in quite inadequate quantities—could do to suppress the epidemics of a disease which was transmitted by means that nobody understood.

Encouraged by Sir Patrick Manson in London, during his leave in 1894–5 Ross concentrated on the study of the connexion between mosquitoes and malaria. In 1878 a French army surgeon, Laveran, first observed the parasites of malaria in the blood of a human patient, by studying blood specimens under the microscope. This quickly led to further observations, and by 1885 the appearance of malaria parasites, as dark spots of pigment inside pale round cells which develop and throw off spores, had been noted in the blood of other animals and of birds.

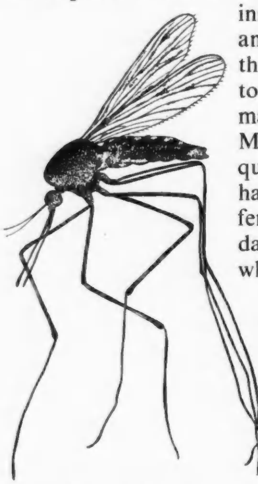
But only guesses had been made as to how the malaria parasite got into the blood and reproduced itself until the corpuscles were all infected by the living spores. And though the guesses included mosquitoes, little was known about the insects and nobody knew for instance that the sort of mosquito infecting human beings might be different from those infecting birds or other animals.

When Ross returned to India in 1895 determined to find out the truth, he himself hardly realized the magnitude of his task, for he had to incriminate the right species out of hundreds, and ascertain how the insect—if indeed it did infect human beings—transmitted the parasites of the fever. In India the authorities were disinclined to favour research work by a member of the medical service, and the microscopic study of bacteria was still a new-fangled notion.

It was therefore after much active official discouragement added to illness and the trying climate of the places where he most wanted to study malaria, that Ross made the great discovery of the pigmented cells of malaria in the tissues of a female Anopheles mosquito.

The weather, that August of 1897, was stifling, owing to the delayed monsoon, and Ross, working in his stuffy little laboratory at Secunderabad, was feeling exhausted after dissecting all but one of a batch of mosquitoes of a kind he had not been able

to dissect before. He had noticed them before, as having dapple wings and by the way they stood with head sloping downwards. It seemed as if once more he was going to draw a blank. He had dissected about one thousand mosquitoes during the previous two years, and each insect dissected under the microscope represented at least two hours of concentrated observation, apart from other worries in securing insects and larvae, and arranging for the bottled insects to suck the blood of malarious patients. Most of the mosquitoes dissected had been of a different sort from this dapple-winged type which had filled him with renewed hope. Now it looked as if this also was innocent. He was inclined to give up work for the day before finishing the mosquito already on the microscope slide. Sweat streamed into his eyes, and the strain on his sight was made worse by a crack in the eyepiece.



A malaria carrier

In his own words—"I went carefully through the tissues with the same passion and care with which one would search some vast ruined cathedral for a little hidden treasure. Nothing! No, these mosquitoes also were going to be a failure. There was something wrong with the theory. But the stomach tissues remained to be examined—lying there empty and flaccid before me on the glass slide: a great white expanse of cells like a courtyard of flagstones—each one of which must be scrutinized.... But I was tired, what was the use?... But the Angel of Fate fortunately laid his hand upon my head...."

He resumed work, and almost immediately saw a dark stain that ought not to have been there. He altered the focus of the microscope to make sure, and with rising excitement realized that he was looking at the pigmented malaria parasite in a mosquito. The next day he confirmed the observation. The parasite had grown larger. And in the last mosquito of the batch he found it again. He was soon able to show that the malaria parasite, sucked from a malarious person, passed through various stages, from the mosquito's stomach into the salivary gland and thence into the next human being that the insect bit. Only the females seek blood, the males being vegetarians, and it has been suggested that the purpose of sucking blood is connected with the development of their eggs.

Ross made some more neat entries in his note-book, sealed specimens to go with his report, and, characteristically, broke into verse: these three little stanzas being part of his famous series called *In Exile* which describes, like a poetic diary, his mental vicissitudes during the laborious researches in India:

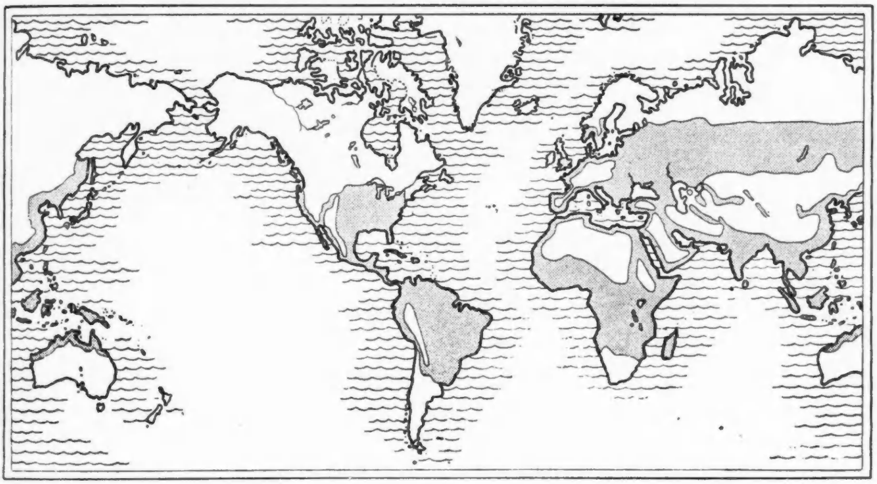
> This day relenting God
> Hath placed within my hand
> A wondrous thing; and God
> Be praised. At His command
>
> Seeking His secret deeds
> With tears and toiling breath,
> I find thy cunning seeds
> O million-murdering Death.
>
> I know this little thing
> A myriad men will save.
> O Death, where is thy sting?
> Thy victory, O Grave?

It is by no means the best of the poems in the series but it is and deserves to be the most famous one. The result of the discovery, as became apparent to the slowest intelligence, was that vast areas of the globe—desolated by malaria—might be made verily to blossom as the rose by

applying the practical measures which Ross, quickly followed by others, devised for abolishing epidemics.

Very briefly, the campaign that had to be waged against malaria—and, as soon became apparent, against yellow fever also—depended mainly upon mosquito-control measures in all thickly populated areas. Choking the larvae in the breeding seasons by spraying water with oil, stocking ponds with fish, drainage work to get rid of avoidable standing water in malarious areas, were the chief acts of warfare against mankind's greatest enemy. The Americans soon made Havana comparatively healthy, and the British did the same for most of "The White Man's Grave" on the West Coast of Africa, though there were opposition and scepticism to be overcome. The rim of the Suez Canal was cleared of malaria, and during the next twenty years an enormously rich plantation area of the Malay States where native life had been moribund because of malaria epidemics was transformed by the expensive but fruitful anti-mosquito measures carried out. Here and there in India valuable work was done, and is still being done, but it was of India and Ceylon especially that Ross in his later years was thinking when he complained of the inadequacy of malaria control work.

When fulsome political speeches about the progress of British tropical hygiene are made, it is as well to remember that the frightful epidemic which swept Ceylon in 1934–5 was the result of neglecting to carry out adequate mosquito control, though the medical services in several respects were also deficient, as was shown by the careful survey, *Malaria in Ceylon*, by Col. C. L. Dunn (1936), a former Director of Public Health in the United Provinces of India.



The shaded parts of the map show where malaria is prevalent

The problem of controlling malaria in India is of course far more complicated, but the governmental measures have been ludicrously inadequate, even in the matter of encouraging the growing of cinchona for quinine, so that India depends upon the Dutch planters of Java for the present supplies, which are about one-twentieth of India's minimum needs anyhow.

Let us not forget that while a million or more people die of malaria every year in

India, and nearly a third of the globe is still malarious, statistics issued in recent years by the League of Nations and the Public Health Commissioner with the Government of India show that in most parts of the world the incidence of malaria tends to increase (unless fuller registration is accountable for the frequently larger figures).

Even in the United States a nation-wide organization has been found necessary to combat malaria, from which at least four million people are estimated, on the basis of incomplete returns, to suffer seriously, while the population that is liable to be swept by local epidemics is of course many times that figure. The federal government now makes grants to the state health departments, mainly in the south-west and south, for well-organized malaria control plans which include the co-operation of an army of civilian volunteers.

The British people who know only England are apt to ignore the importance of using the knowledge and experience that have been gained through Ross's discovery; and the unpleasant fact that the British Empire is also a highly malarious Empire ought to make "Mosquito Day" a pretext for useful propaganda as well as the celebration of a great triumph for medical science.

Reviews

A Nature Lover in British Columbia

A Nature Lover in British Columbia, by H. J. PARHAM (Witherby, 8*s.* 6*d.*)

THE author of this pleasantly written book lived with his family and friends first on a ranch in the Okanagan Valley of British Columbia and then in the neighbouring town of Penticton. He is a keen observer of animals, birds and wild life, and his chapters afford British readers an opportunity of gaining first-hand information about the denizens of remote Western Canada.

Scientifically the appendices containing lists of mammals, fish, birds and flora of Okanagan will be useful to students. Dog lovers will enjoy the many stories the author tells of Banjo, a cross-bred half retriever and half setter, a most intelligent and lovable animal; in fact, "a gentleman", as one of his friends described him.

Readers of Grey Owl's books will be glad to learn that some beavers still survive in Okanagan: most of them are locally known as bank beavers, and bore holes in the river banks instead of building lodges and dams, but Mr Parham mentions one small beaver dam which turned a spring into a pond. Marmots ("ground-hogs") are common; coyotes, or prairie wolves (the name was originally *coyotl*, from the Mexican), are a nuisance; among larger mammals may be mentioned mule deer and bighorn or mountain sheep. Trespassing skunks, the author says, do not make themselves odoriferously obnoxious if shepherded tactfully away from your shack.

Birds evidently have a strong hold on Mr Parham's affections. He writes charmingly of Canada geese, a species introduced into England more than 200 years ago and now numerous on Cheshire meres in a semi-wild state. He hatched six goslings under a hen and two of them survived two shooting seasons. One of them mated with a wild gander, and nested in a box in the porch of the bungalow. Another pair hatched their eggs in an osprey's nest ninety feet up in a fir tree; how the goslings reached the ground was never discovered, but apparently they did so without injury. The usual site of the nest is on the ground. Ospreys sometimes use the nest after the geese have finished with it: they were harried by bald-headed eagles until the latter were destroyed, so Mr Parham states, by order of the game warden.

Golden eagles nested near the ranch, and on the ranch itself the author observed many varieties of birds: Nuttall's Poor-will, a species of nightjar; "robins" (American); blue-birds, delightfully tame, which nested in a box near a door of the shack; meadowlarks (really starlings) with ventriloquial songs; mourning doves; Clarke's nutcrackers; Lewis' woodpeckers, destructive of apples; Western crows, who steal eggs but perform wonderful aerial evolutions, and many others. Wood-warblers (the American family, Compsothlypidae) are not, Mr Parham says, great singers; the vireos warble better. Sparrows and finches are an enormous family. The showiest birds are the Western tanager, crimson, yellow and black, and Bullock's oriole; woodpeckers are many and various. Game-birds include several species of grouse, ptarmigan, quail, partridge and pheasant.

The chapter entitled "Save the birds" is melancholy reading. Apparently the

Canadian Migratory Birds Protection Act is no more effective than our British Wild Birds Protection Laws. There, as here, the collector pest is rampant. One collector shot a series of female lazuli buntings in order to ascertain how many mates a single male would acquire in succession, a typical piece of "scientific" stupidity. Mr Parham makes a strong plea for better protection: if, as he states, the Government's Protection Officers are allowed to kill rare birds for their own collections the situation appears pathetically Gilbertian.

Other chapters describe the making of a garden in the author's town home and the various birds that he attracted to it. It must have been a lovely sight to see three kinds of humming-birds round his red and white flowering currants. Altogether a useful and attractive book.

E. W. HENDY

Mr E. W. Hendy asks us to point out that there was a printer's error in his review of Messrs Witherby's *British Birds* in our June number. The name cited in connexion with the corn-bunting should have been that of Col. and Mrs Ryves.

The Science of Society

An Introduction to Sociology, by J. RUMNEY. (Duckworth, 3*s.* 6*d.*)

THIS excellent little book is a fitting sequel to the author's earlier work on Herbert Spencer's Sociology. It will reach a larger public and, though dealing with more general questions, it is at the same time more practical. For it raises the issue, "Why have we only one professor of sociology in Great Britain?" and "Why is sociology as such generally discredited among us, especially at our older seats of learning?" Sociological questions are of course debated everywhere and there are professorial chairs which might well be called sociological. But sociology, as the general study of human relations, is suspect as a science. And Mr Rumney gives us a satisfactory answer to both the questions; (1) whether these questions should come together within the framework of one science, to which the Comtian name of "sociology"—the last constituted of the sciences—may be properly applied; (2) why English academic opinion has for the most part declared against it.

The only chair of sociology in the

country is that at the London School of Economics now held by Morris Ginsberg. It was instituted by the private munificence of Mr Martin White and practically in honour of L. T. Hobhouse, who contributed more to the building up of the science in England than any other man, much more in general theory than even the colossal labours of Herbert Spencer. If any one could have freed sociology from the prejudice under which it has always laboured among us, it would certainly have been Hobhouse. Perhaps he may still do so, for being dead he now seems to speak with greater acceptance than when he was alive. His definition of the subject matter of sociology is "the interaction of human minds". It might be said that this is too narrow, limiting the subject to psychology or even to one branch of psychology, viz. social psychology. Hence one welcomes the rather wider terms which Ginsberg uses, himself an ardent disciple of Hobhouse. "Sociology", says Ginsberg, "is the study of human interactions and interrelations, their conditions and consequences." Here we have not only social psychology but ethics, law, economics and history, all of which have a large part to play in constituting the science of sociology as a whole. One must leave Mr Rumney to convince the reader himself that these things should be gathered together under one roof. He does this in the most temperate, conciliatory and convincing way, touching in various chapters on the origin and rôle of property, class, family and environment in the history of mankind. But a word must be said on the *non-possumus* attitude of the academic British public. Mr Rumney has some interesting remarks on this point at the end of his book after noticing the recent institution and work of the Institute of Sociology. He attributes the adverse attitude of the universities to sociology partly to the view taken of Herbert Spencer who was not a university man and whose teaching was regarded as naturalistic and materialistic. But there are deeper reasons. Sociology has been the product of rapid change and crisis, and the genesis of Comte's sociology on the heels of the French Revolution is the most striking instance of this. But in England where change has always come gradually and piecemeal, there has never been the same strong motive to consider and overhaul the foundations of society as a whole. The result was a naïve empiricism and a disinclination to co-ordinate the social sciences. With us they have generally been pursued separately and in a practical spirit. The evolution of our legal system, without a code, and of our parliamentary system, without a written constitution, are parallel instances. But, Mr Rumney concludes that, in this age of rapid change and universal planning, the time has come for more systematic co-operation between the many branches of scientific social investigation. To be effective, to help one another and to avoid contradiction and overlapping, they need a sociological framework. Let us then begin in earnest to see social life steadily and see it as a whole.

F. S. MARVIN

KS

er): "Musi-
e book of

eing neither
d this book

expect from
asy flow of
never ob-
ook urbane
dull."

y man of
omwell and
free speech,

tands alone,
whole field

as done for
evelyan has

r times. It
gn Policy in
A. Spender

A work of
rly written,
"

nplete, satis-

: "In every
s a reference
it is full of

h): "I salute
he whole of
verse-trans-

Rose is that
What he has

e Observer):
narrative."